IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

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Engineering Library

THE profession of engineering in the United States comprises not alone scientific advisers on industry, but, in great majority, is comprised of the men in administrative positions. In such positions they stand midway between capital and labor. . . . . They have that faculty of mind for quantitative thought, as distinguished from qualitative thought, that takes such problems as this (of the coal industry) out of the region of politics into the region of matter-of-fact solution.

Herbert Hoover in addresses before the February, 1920 meeting of the A. I. M. E.

OCTOBER 1920

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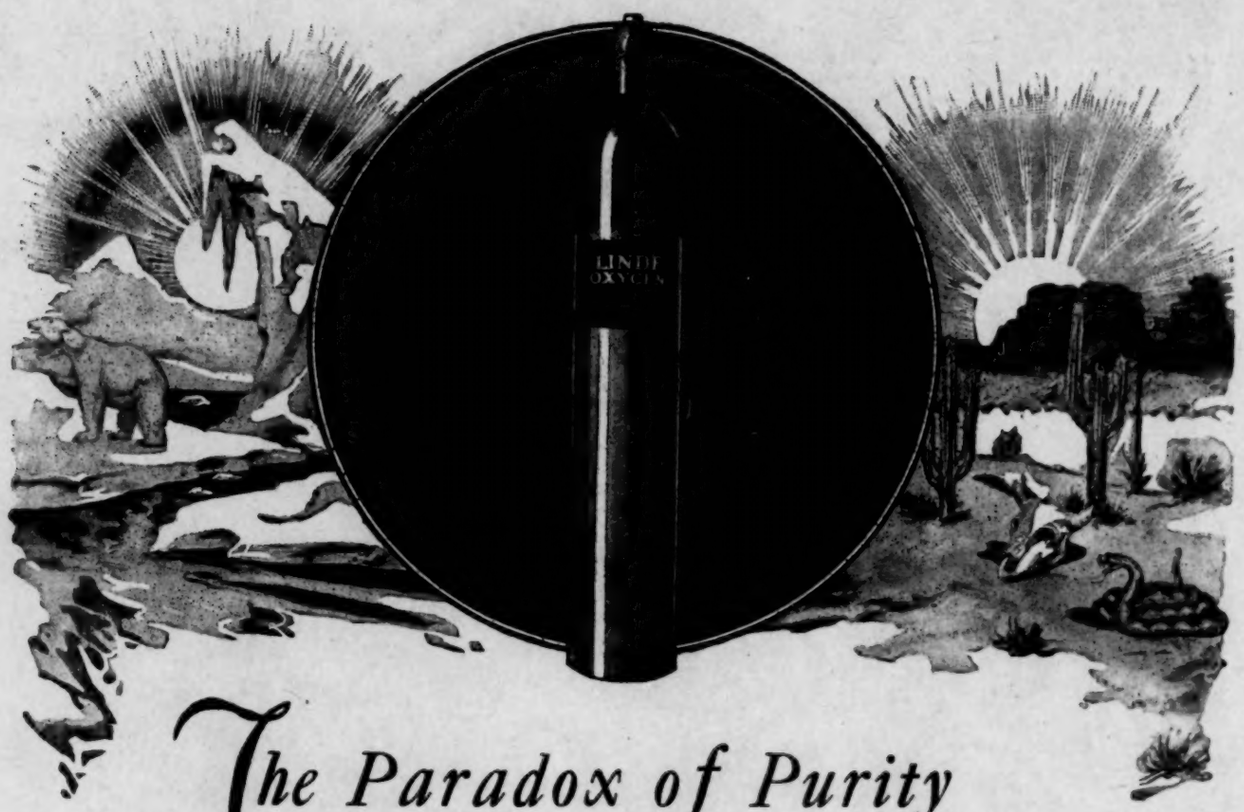

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Mechanical Engineering

Including The Engineering Index

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C. 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

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Contributors and Contributions

Fundamentals of Appraisal and Valuation in Engineering Practice

The series of appraisal papers in this number was presented at the last Annual Meeting of The American Society of Mechanical Engineers and further discussed at the last Spring Meeting, at St. Louis. These papers were arranged for by a committee consisting of Dean M. E. Cooley, Past-President, and J. R. Bibbins, the author of the first paper, and give progressively the historical basis for the economic conditions affecting appraisals, a discussion of conditions met with preliminary to actual completion of a project, and a brief survey of valuation practice. In introducing his paper at the Annual Meeting, Mr. Bibbins called attention to the seriousness of the present situation brought about by the lamentable failure of engineers to agree upon a codification of their definitions, methods, and practices in valuation procedure, especially when ultimate decisions must finally rest upon the shoulders of courts, commissions, or non-technical bodies. A policy of open-minded coöperation, research, and education along fundamental lines of economics is urged, rather than a continuance of purely partisan methods of thought and action.

J. R. Bibbins

Experiments on Ozonating Water

An extensive series of experiments lasting over a period of years was carried out by A. E. Walden of the Baltimore County (Md.) Water and Electric Co. to perfect the design of apparatus for ozonating the water supply of communities. The readers of this Journal are fortunate in having a summary of the results of this important work in an article in the present number by Mr. Walden.

Data on Electric Welding from Bureau of Standards and Westinghouse Company

Two contributions to the records on Arc Welding are included in the current issue through the able offices of the Washington Section of the A.S.M.E. During 1918, at the request of and with the coöperation of the Welding Research Sub-Committee of the Emergency Fleet Corporation, an extensive program was outlined by the Bureau of Standards for the Study of Electric Arc Welding of Steel. The first paper, by Henry S. Rawdon of the Bureau of Standards, a presentation of a portion of the Bureau's results, treats of the properties of the arc-fused metal, upon which the efficiency of the weld is dependent. In the second paper, O. H. Esehholz of the Westinghouse Electric and Manufacturing Co. describes the basic phenomena occurring, as well as the weld properties obtained when employing the metallic electrode process.

Depth of Copper Plating Necessary to Prevent Carburization of Steel

An investigation was conducted by F. P. Zimmerli at the University of Michigan to determine the necessary depth of copper plating when employed as a non-carbonizing material on steel. While copper plating is largely used for this purpose, apparently but little information has been published on the least amount of copper which must be used to prevent the penetration of carbon into the steel within a specified time. In carrying out his experiments, the author found that his results agreed very closely with those given in the paper on case carburizing, by Marcus T. Lothrop, presented before the A.S.M.E. in 1912, but obtained by an entirely different method.

For the Professionally Spirited Engineer

The Correspondence Department in the current issue is worthy of careful perusal. The greatest American development in engineering organization, The Federated American Engineering Societies, is the topic of discussion by Charles Whiting Baker and Howard Coffin. Neither of these men require introduction to the engineering reader.

The increased standing of the engineering profession in this day of advanced civilization brings a discussion of a Code of Ethics to the foreground of interest. Professor Christie is chairman of the committee that drafted the A.S.M.E. Code. To render a code satisfactory to all engineering points of view is no mean labor, and Professor Christie's request for careful consideration is entitled to attention from every engineering reader.

American Engineering Council of F. A. E. S. to Hold First Meeting

Further information upon The Federated American Engineering Societies is given on page 596, with the program of the first meeting of its governing body, to be held in Washington, November 18 and 19. Several additional societies have joined the Federation, which has already become a strong and going organization.

James Hartness Nominated for Governor of Vermont

The latest prominent example of the entry into public affairs by engineers is the recent nomination of James Hartness, Past-President of the A.S.M.E., as Republican candidate for Governor of Vermont. The story of his campaign, which was entirely unique, is told in this number.

A.S.M.E.

ANNUAL MEETING

December 7-10, 1920

The 1920 A.S.M.E. meeting will feature the presentation and discussion of the transportation problem. Six Professional Sections will hold sessions. A session on Woodworking and a number of important general papers are assured.

For complete information on A.S.M.E. Affairs See Section Two of

MECHANICAL ENGINEERING

MECHANICAL ENGINEERING

Volume 42 October 1920 Number 10

Appraisal and Valuation of Properties

Rational Valuation; Price Levels in Relation to Valuation; Cost of Organizing and Financing Public Utilities; Interest and Taxes During Construction; as Discussed at St. Louis Meeting of A.S.M.E.

IN response to frequent requests from engineers for a discussion of the appraisal and valuation of property, sessions for this purpose have been held at the last two general meetings of The American Society of Mechanical Engineers. In arranging for these, a special effort has been made to contribute results of definite value in the broad field of appraisal and valuation. By such discussions as these it is hoped to bring about practical coöperation among members of the engineering profession, so that new light and more effective guidance may be given to the courts and commissions who in the end are obliged to rely upon technical findings in reaching equitable judgments.

At the two sessions mentioned, five papers were presented, of which one, Methods of Appraisal and Valuation, by David H. Ray, has already appeared in MECHANICAL ENGINEERING.[1] Abstracts of the other papers appear below. These papers are as follows: Rational Valuation, J. R. Bibbins; Price Levels in Relation to Valuation, Cecil Elmes; Cost of Organizing and Financing a Public Utility Property, F. B. H. Paine; Methods of Computing Interest and Taxes During Construction, H. C. Anderson.

The purpose of the first paper is to emphasize the breadth of view which a complete valuation should hold in order to be of the greatest usefulness, especially with reference to the facts of history. The author makes a comparative study of valuation practice illustrated by a complete economic analysis of a large utility from the period of the Civil War to the present time, yielding in substance the history of the five-cent trolley fare.

Similarly, the second paper is a study of commodity prices. The author traces the changes that have taken place in prices and wages in this country and England since very early times. He believes that greatly reduced commodity prices are not to be expected unless lower wages are to be taken for granted. He further points out that the laws of economics as outlined in the paper must apply to public utilities as well as to other things, and that in any proceeding the word "dollar" should not be used to mean two different amounts, a high figure to one party and a low figure to the other in one and the same controversy.

The third paper discusses the preliminary steps which must be taken before a project is finally launched. These embrace the development of the project and the securing of sufficient capital funds for preliminary outlays and for the actual construction of the utility.

Finally, the fourth paper takes up the proper allowances to be made for interest and taxes during the period of construction—items frequently ignored in the early days of appraisals and for which latterly excessive figures have often been used.

At the first session at which the papers were presented, the time was given almost entirely to the reading of the papers. In MECHANICAL ENGINEERING for July 1920, there is a summary of the discussion of the papers which took place at the second session held at St. Louis last May.

Rational Valuation—A Comparative Study

By JAMES ROWLAND BIBBINS,[2] CHICAGO, ILL.

VALUATION should be characterized as cold fact and engineering judgment combined. We should at least agree on facts. To clear the decks, let us eliminate what may be regarded today as the established mechanics of the valuation method. All of the factors noted below are probably admissible as facts, although the specific rates of construction overhead (items 7-10) may be subject to discussion and variance according to the kind of property, the locality and the historical period during which it was built. Then follow the principal contestable factors.

ADMISSIBLE FACTS

1 Extent of property owned and establishment of unencumbered title
2 Physical inventory in detail or by type of percentage-method according to accuracy desired. (Engineering approximations favored)
3 Cost extension based on original voucher costs or representative normal average costs. (Current costs as of date used in special cases)
4 Age of original structures still in use and property superseded
5 Normal life and rate of renewal encountered in shorter-lived property under peculiarly local conditions, such as ties, investment in an established property?
6 Initial expenses, legal and otherwise, incident to organization and construction
7 Engineering and superintendence prior to and during construction—i.e., cost of construction organization.
8 Specific carrying charges, such as interest, taxes, insurance during construction
9 Discounts on construction finds not covered by normal interest rates
10 Accrued depreciation existing as a physical fact, not considering, for the moment, its application.

CONTESTABLE FACTORS

1 Purpose of the valuation as affecting "value":
(*a*) Taxation (*b*) Accounting (*c*) Condemnation
(*d*) Rate-making (*e*) Purchase or Transfer
(*f*) Capitalization, and recently, during high prices
(*g*) Insurance
2 Original Cost vs. Cost-to-Reproduce New theory under
(*a*) Original conditions of construction, or
(*b*) Conditions today with modern substitute plant
3 "Original Conditions" logically associated with actual Cash Costs (actual investment). Likewise current prices today with substitute plant where obsolete elements are considered
4 Appreciation in values since original construction, principally in real estate and earning value, recently in all material and labor.
5 Accrued depreciation on physical elements due to age, wear, inefficiency, and being out of date (obsolescence)
6 Franchise value, early losses, going concern, cost of developing the business, good-will, etc., asset or liability, or neither?
7 When does a business drop from a "going concern" to a "losing venture" and necessarily subject to lower return?
8 The range of applicability of current or "spot" prices: (*a*) Boom prices; (*b*) Panic prices. Has a spot value (as of today) any weight in an absolute determination of capital investment in an established property?
9 Should the true cost of service include at all times as an element of operating expenses, the wearing down or depletion due to accrued depreciation?

SCOPE OF A COMPLETE VALUATION

From the above it will be apparent that to attempt intelligent discussion of "Value" involves sidetracks and pitfalls in hopeless

[1] December, 1919, p. 931.
[2] Supervising Engineer, The Arnold Co., Mem. Am. Soc. M. E.

number, unless the issue is most clearly defined and limited. For it is a fact that, by reason of contractual requirements, public necessity, and the rights of society of past, present, and future generations, not to mention the investors, business with its risks and its responsibilities has reached an exceedingly complex stage. So that it no longer suffices to value a great property as a boy's jack-knife, "unsight—unseen." The writer submits instead that a proper valuation must view the subject from all possible angles, such as:

a The actual true plant investment cost as built, from historical studies
b The cost to reproduce plant as it exists today under reasonably normal prices—i.e., neither boom nor panic prices, which is a check on (*a*)
c The cost to develop the physical property to its present state of efficiency; called Plant Development Expenses
d The money loaned for commercial development, called Deferred Earnings during development
e The present shrinkage in physical plant from aging or other form of depreciation
f The contractual and moral responsibilities of the owners to the public and vice versa
g The history of development, net income for fixed charges and true adjusted return on net plant investment.

In other words, valuation especially for rate-making purposes has risen from simple arithmetic to the high level of an economic science requiring the utmost power of analysis, accounting judgment and vision. It demands the facts from the past, the conditions of the present and the outlook for the future.

Upon this substantial foundation may then be built up the case in question. In fact, a rate case rests upon a so-called three-legged stool, the economic stability of which rests in turn upon (1) Basic Value Assigned, (2) Rate of Return allowed on that value, (3) Disbursement of Income. To shorten any leg overturns the stool.

Time was, with the phrase "Public Utility" yet unborn, when properties were conceived, built, and operated distinctly for personal or corporate profit, without restriction, just like the industries furnishing the equipment. The major difference between utility and industry rested upon that intangible asset (or liability) called a franchise. Thus came to be established the personal point of contact with the public; in railways the most intimate, in telephones less so, and in light, power, and gas the least. And right here, unconsciously, industry became the public's business, as time and bitter experience have proved.

But here was the rub; when the utility industry awoke to the true cost of service based upon proper cost accounting, the balance sheet footed red. With income practically fixed, costs rising, depreciation mounting and right to do business expiring in the face of new conditions imposed by a more intelligent public, a readjustment became inevitable.

Meanwhile, private industry boomed, under no restraint as to right to do business and enjoying flexible rates to absorb variations in cost of service, with no limit except that imposed by competition. Hence earning power became the principal basis of capitalization as it has been to an unfortunate extent in the early acquisition of utilities. The difference was that, while perhaps justified in industry, it was not justified in the case of utilities, owing to the specific incumbrance of the franchise.

The economist, John H. Gray, has shown[1] that Federal regulation was devised to limit risk by preventing speculation and thereby to stabilize values accordingly—i.e., a police power which has already been exercised in the cases of utilities, banks and insurance companies, but only now taking form in the case of the private industries. Also he has demonstrated that the real difference between public and private property is that one is subject to the "servitude" or incumbrance of specific public service, the other is not, and that this incumbrance entirely vitiates franchise value, which itself is dependent upon rates fixed by public authority. Here we run around in a complete economic circle.

Is any one wise enough to deny the possibility of ultimate Federal regulation over industry such as that of the Interstate Commerce Commission over common carriers, and that such control will be based on the following principles:

a Actual investment cost contributed by the owners
b Rates calculated upon this investment
c Variable risk, requiring varying charge rather than variable value.

In other words, to stabilize values by eliminating the speculative element more and more, in essential industries.

It appears to the writer that fundamentally utilities and industries are not dissimilar as to the various aspects of valuation relating to the physical properties; and that only the speculative element is shrouded in doubt, which at least is minimized in the utilities subject to public regulation and protection.

THE VALUE OF ECONOMIC RESEARCH

At the very foundation of rate making lies the determination of the true Cost of Service, or of product. It is no exaggeration to say that much of the controversy over valuations could have been avoided entirely had it been possible for the contending parties to view the complete facts concerning which there could be little or no argument.

Concerning the valuation basis, it is a matter of common knowledge that the partisan viewpoint has performed wondrous acrobatics in shifting from actual investment to replacement cost, then back to original cost, and again to cost to reproduce new on current prices. In earlier usage, "cost to reproduce new" was generally held to mean cost to reproduce in brand-new condition the property inventoried, under construction conditions and prices prevailing. Later, the definition was broadened somewhat in general usage so as to mean "cost to reproduce new," under substantially "original" conditions, the property inventoried, using normal prices or prices averaged over a term of years where wide fluctuations occurred. Quite recently, the scope of valuation has undergone still further modifications in the effort to satisfy the condition where the owners are held entitled to receive "a fair and reasonable return on the actual investment," which requires the determination of the historical value, i.e., the total actual cash investment resulting from efficient administration in (1) producing the property, (2) operating it efficiently, (3) extending it as required and (4) maintaining it at the physical standards necessary for reasonable requirements of the service. This later interpretation of "cost to reproduce" obviously attempts to reproduce the original cost and in fact, were no historical records available, such a value would probably represent closely the original cost of a property built in times of normal conditions and prices.[1]

Looking, then, into the future of valuation methods, can we escape the necessity of visualizing original cost at least as the starting point of valuation, in any direction of enterprise, and with the facts available as revealed by economic research, will there not be far less to squabble about?

OPENING THE DOOR OF THE PAST

In order to crystallize the principal thoughts presented in this paper, a typical case may be used for purposes of illustration.[2] The exhibits represent a comprehensive study of all phases of development of a typical railway property from its inception, keeping an open mind as to what constitutes fair value for rate-making purposes today and taking into consideration essential economic elements of past, present and future. This is a deliberate attempt to illuminate the complex problem confronting society as a whole in fairly distributing the burden of development and operation of its public utilities. The study presents what may be termed the problem of three generations and illustrates, it is hoped, in unmistakable terms, the practical difference between renewals (or completed depreciation), accrued depreciа-

[1] Trans. Am. Soc. M. E., 1916, p. 1247.

[1] The single exception is the appreciation of realty values by time and development. Some deny the right to appreciation over actual cost. However, it seems clear that land is a somewhat different classification from other physical property. And there is also involved an exceptional factor —viz., that the public, by taxation, recognizes value at least to the extent of the taxables reported; it could not justly deny value and tax it too.

[2] Presented by courtesy of Bion J. Arnold, Consulting Engineer, Chicago.

tion (or unmatured renewals), and amortization (a purely actuarial process designed to liquidate a debt). Further, the study shows the essential need of a definite amortization policy under all franchises of finite term and especially under short-term franchises. And here is the cause, usually neglected, of most of the contention over the admissibility of depreciation; i.e., whether the principal of the funded debt can be paid back, at expiration of franchise, either directly or by previous amortization.

HISTORY OF THE FIVE-CENT FARE—FIG. 1

Net Investment, the upper curve, shows the progress and growth of a typical property and should be held in mind as an approximate measure of the relative size of the property and volume of operations for the early and late periods of development. This represents the actual property in operation as would be determined by inventory at any year, at the original cost, i.e., all superseded and abandoned property is deducted. It will be noted that the horse-car operations are relatively unimportant, as the horse property was only about one-fourth the size of the electric property today, and would probably average not more than one-fifth.

Annual Rate Earned curve indicates the annual net income balance (applicable to fixed charges, amortization, and surplus) in per cent of the average net investment for the year. In computing this return, the superseded and abandoned property is

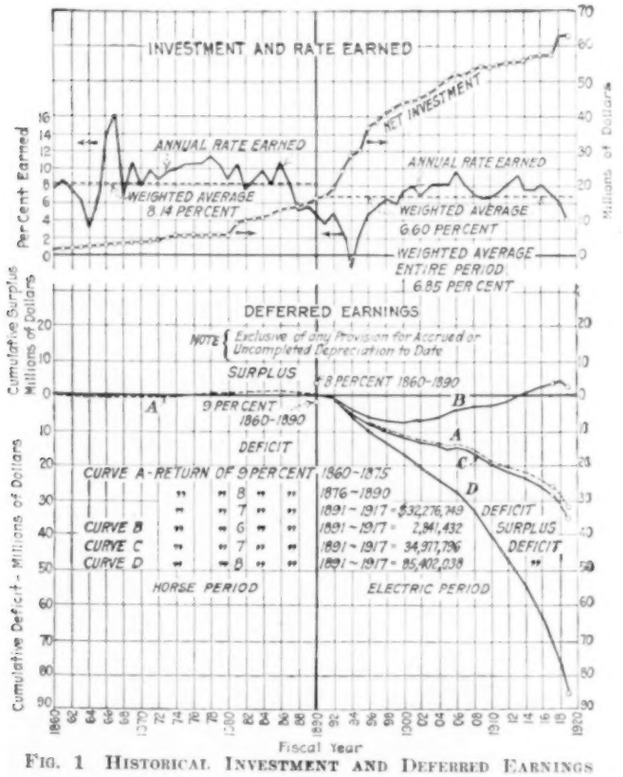
INVESTMENT AND RATE EARNED
NET INVESTMENT
ANNUAL RATE EARNED
ANNUAL RATE EARNED
WEIGHTED AVERAGE 8.14 PERCENT
WEIGHTED AVERAGE 6.60 PERCENT
WEIGHTED AVERAGE ENTIRE PERIOD 6.85 PER CENT
Per Cent Earned
Millions of Dollars
DEFERRED EARNINGS
NOTE { Exclusive of any Provision for Accrued or Uncompleted Depreciation to Date
SURPLUS
8 PERCENT 1860-1890
9 PERCENT 1860-1890
DEFICIT
CURVE A - RETURN OF 9 PERCENT 1860-1875
" " 8 " " 1876-1890
" " 7 " " 1891-1917 = $32,276,749
CURVE B " " 6 " " 1891-1917 = 2,841,432
CURVE C " " 7 " " 1891-1917 = 34,917,796
CURVE D " " 8 " " 1891-1917 = 85,402,038
DEFICIT
SURPLUS
DEFICIT
HORSE PERIOD
ELECTRIC PERIOD
Cumulative Surplus Millions of Dollars
Cumulative Deficit - Millions of Dollars
Fiscal Year

FIG. 1 HISTORICAL INVESTMENT AND DEFERRED EARNINGS

charged off in the year superseded. As a matter of fact, practically no amortization reserves have been built up in this property to absorb accrued depreciation by reason of the evident insufficiency of income of past years. The annual rate earned is then more apparent than real.

Deferred Earnings, curve *D*, shows the cumulative surplus and deficit in this net income balance, or, in other words, the relative possibility of the electric lines as a whole earning an assumed fixed rate of 8 per cent on the net investment for fixed charges, amortization, and surplus. Consequently, the downward tendency of curve *D*, after electrification was completed, really indicates the true trend of electric-railway operations in comparison with the income realized from the rates of fare actually established and in force. These deficits were compounded at this rate as they had to be funded; likewise the surpluses. Curve *C* corresponds to a rate of 7 per cent and Curve *B* to 6 per cent, for the electric property. Curve *A* covers the entire history horse and electric operation corresponding to a rate of 7 per cent electric period and 8 to 9 per cent during the horse period, the rate of the early years recognizing the higher cost of money commensurate with the risk involved.

The zero line of Fig. 1 obviously represents par; i.e., for a continuing, stable business there should be no cumulative surplus or deficit at a rate of return, taken over a long period, adequate for the support of this investment. Now the hard facts which

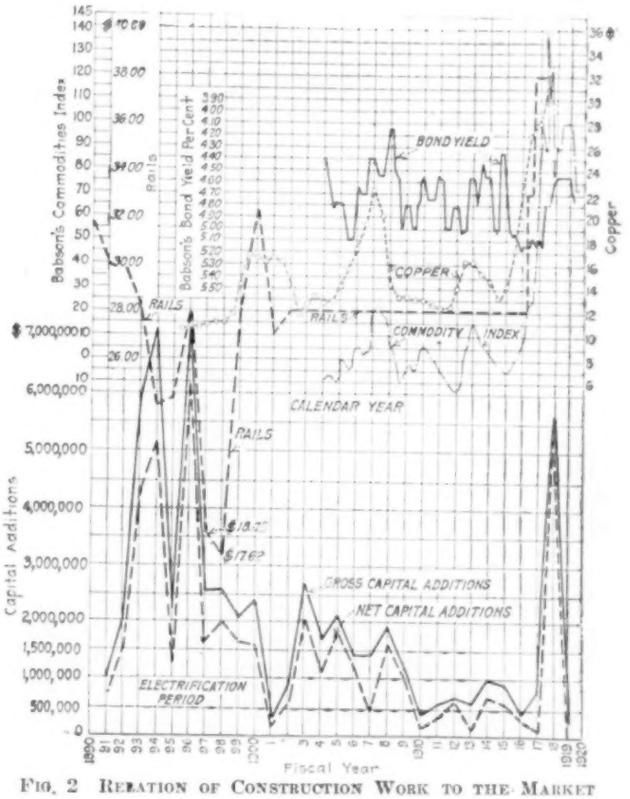

FIG. 2 RELATION OF CONSTRUCTION WORK TO THE MARKET

the owners of these properties face today as drawn from this typical economic study may be summarized as follows:

Apparent Rate Earned, 1860-1890	6.85 per cent
Apparent Rate Earned, Electric Period, 1891 to 1919	6.60 per cent
Actual Rate Earned, Electric Period, corrected for actual deficits and crediting surpluses	6.10 per cent
Actual Rate Earned, Electric Period, further corrected for assumed amortization of Accrued Depreciation to date	5.27 per cent
Actual Rate Earned, Electric Period, finally corrected to cover Renewal Fund payments necessary to meet future Renewal Liability (basis, pre-war normal prices)..	5.03 per cent

All rates expressed as weighted averages.

Thus the actual economic history of electric operation in this property is seen to be on a true basis of about 5 per cent, which would necessitate in financing 4 per cent bonds and 6 per cent stock, assuming the same amount of each issued on the property. Obviously, enormous discounts could not very well be avoided on such a basis.

RELATION OF CONSTRUCTION WORK TO THE MARKET—FIG. 2

The lower curves trace the rate of capital investment per year in the electric property (and the extensive supersession) as compared with the upper curves of market price levels. Evidently the major construction and reconstruction work was not carried

out during periods of excessively high prices, which has an important bearing upon the study in substantiating the Original Cost appraisal basis. (The apparent exception for 1918 capital additions is explained by the fact that the abrupt increase for the year is due to taking over property formerly rented.)

ADJUSTMENT CURVE OF DEFERRED EARNINGS—FIG. 3

This curve is designed to interpolate rates and earnings between the curves *B*, *C*, and *D* of Fig. 1, so that one may find an expression for the particular rate which he considers "fair" for such a property. The curve measures the deferred earnings of the electric period resulting from the assumption of any given apparent rate earned. Thus, this property averaged 6.60 per cent, but without any provision for funding deficits or meeting Accrued Depreciation. The curve shows that to carry these deficits an annuity of 0.50 per cent was required, reducing the actual rate earned at part to 6.10 per cent (amortization would further lower it 0.83 per cent and renewal liability 0.24 per cent, or to 5.03 per cent final return). It will now be apparent that the financial policy of a utility as compared with an industry

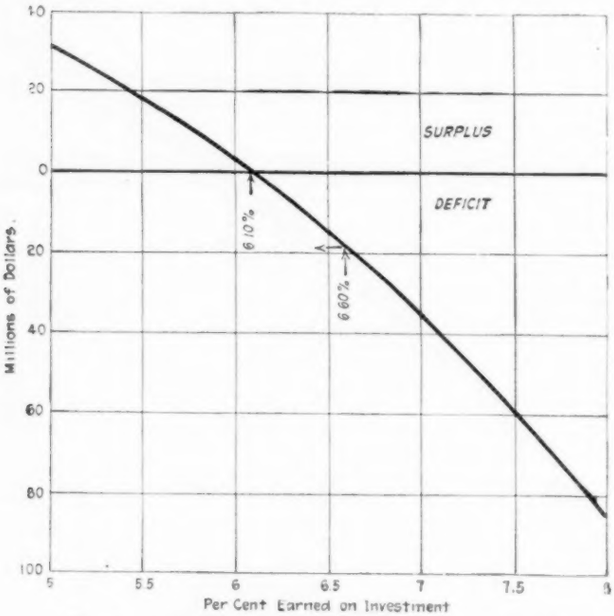

FIG. 3 ADJUSTMENT CURVE OF DEFERRED EARNINGS

may be extremely handicapped by the deficiency in income resulting from a too rigid bargain for franchise and fares.

ESTIMATED FUTURE RENEWAL LIABILITY—FIG. 4

How many properties make a serious attempt to ascertain with any degree of accuracy their future renewal maturities, such as illustrated in Fig. 4? At the left, the actual costs of past maintenance and renewals are shown, rising to a maximum, equivalent to 20 per cent of the gross earnings. Then came the retrenchment of war years, and the actual physical renewals were even less than the money renewals because of the higher cost. Here is a renewal program based on original cost and reflecting exactly the depreciation schedules of the appraisal except that maturities were spread so as to lessen the severity of the peaks.

The principal result shown is that the future requires about $1,300,000 per year to maintain the integrity of the property. Obviously, the only sensible way to meet this condition is by a renewal fund just sufficient to carry the property over the maximum peak of the future. To amass such a fund by the year indicated, 1923-24, would have required an annuity of 0.24 per cent during the entire electric period. This explains the term used, renewal liability.

THE THIRD GENERATION, PAY-AS-YOU-GO, OR PAY-DOWN—FIG. 5

We now come to the crux of the entire problem under discussion, a problem as broad as that of society and social justice. In view of the rapid advancement of the art and the impossibility of foreseeing the ultimate result of rigid franchises granted long years ago, what financial plans with respect to rate making can be devised which will hold the maximum of justice and fairness to investor and public and distribute most equitably the cost of service and cost of development without economic shock? Three typical plans will illustrate.

Plan *A* assumes a "fair deal" as to franchise expiration—i.e., either a continuing or indeterminate franchise requiring necessarily no amortization of either funded debt nor depreciation; in other words, the "pay-as-you-go plan," renewing the property only as fast as the maturities indicated by Fig. 4. Here each generation takes care of itself; pays for renewing plant actually worn out by its predecessors, and passes on to the future its own burdens. In a normally expanding and renewed property, however, this plan is the simplest and cheapest.

Plan *B* assumes a definite expiration of franchise and actual liquidation of the business. Obviously there is no other alternative than an amortization fund to validate the principal of the investment when the property is taken over by the city at "actual present value" (and there is little reason to believe that this will be any other than Original Cost New less Accrued Depreciation, despite present-day contentions for boom prices). Here, then, the rate must include an amortization charge depending upon the contractual term of the franchise. This plan holds practically the only fair economic solution if Public Policy has set definitely towards Depreciated Value as a basis of rates.

Plan *C* interprets the result of a determination to adopt depreciated value at once as a rate basis. This means that 20 to 30 per cent of the investment must be liquidated, provided sufficient returns have not been earned in the past over and above fair return to absorb this shrinkage. But Fig. 1 has shown this not to be the case. There is then no other reasonable alternative but to transfer the amortization charge to the future as in Plan *B*, basing rates on a gradually reducing capital value resulting from the progressive amortization. As a result the public would be supporting, in 1942, an investment no greater than in 1898, although the actual property would be 50 per cent larger.

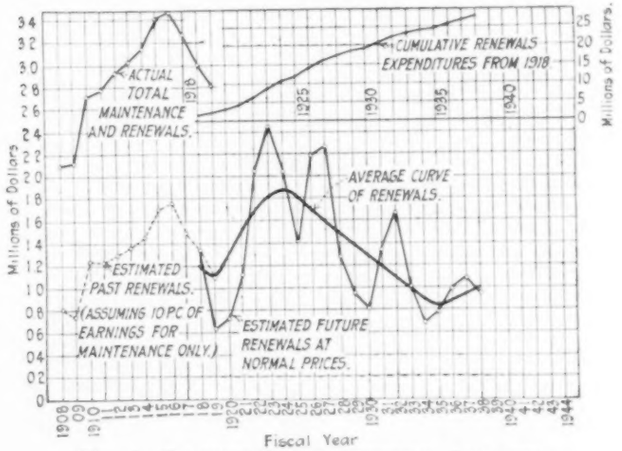
CUMULATIVE RENEWALS EXPENDITURES FROM 1918
ACTUAL TOTAL MAINTENANCE AND RENEWALS.
AVERAGE CURVE OF RENEWALS.
ESTIMATED PAST RENEWALS. (ASSUMING 10 PC OF EARNINGS FOR MAINTENANCE ONLY.)
ESTIMATED FUTURE RENEWALS AT NORMAL PRICES.
Millions of Dollars
Fiscal Year

FIG. 4 ESTIMATE FUTURE RENEWAL LIABILITY

Assume that depreciated value is today in fact imposed by courts and commissions. Then the following alternatives hold in this particular property:

a The past generation has accepted service at less than cost and the franchise bargain was a bad one and the shrinkage a dead loss, or

b The present and future might accept a double amortization charge sufficient to refund at some future date (which is unthinkable) both the shrinkage and deferred return thereon.

But the concluding fallacy is exposed also in Plan *C*, for in this property an inventory each year between 1923 and 1938 would

show an actual depreciated value in excess of the assumed agreed value today (neglecting for simplicity capital additions). The conclusion is plain—that depreciated value as a rate basis must be reappraised annually, or determined currently by a perpetual inventory and inspection (depreciated by the usual methods); otherwise, confiscation plainly enters into the controversy, as shown graphically by Fig. 5. Obviously such a method of current valuation would result in the maximum expense and complexity. If we had made sensible bargains in the past, with sufficient rates for a "pay-down plan," depreciated value might be acceptable in principle. That is, if past riders had actually paid for the property *they* wore out, in full; but this was rarely the case.

The economic conclusions from the study are either (1) that the electric railway has been a losing venture, and therefore should be scaled down to a new par securities basis, or else (2) that the public's responsibility has been unintelligent in permitting malnutrition while accepting service below cost. The responsibility is certainly mutual although rarely considered so, except by the aggrieved party.

Facing the Facts

Is it not clear from the foregoing that the vagaries and inconsistencies of appraisal procedure could have been largely avoided thus:

1 By closer study of past history
2 Economic research into all fundamental facts
3 Reasonable forecast of future income and liabilities
4 More complete appraisal reports dealing with every aspect of reasonable value
5 An open mind—not trying to find the answer before we start
6 Acceptance of accrued depreciation as a physical fact to be handled like any other actuarial problem
7 Cost to reproduce theory used judiciously to reflect the original cost as nearly as possible
8 Institution of perpetual inventories and values based upon well-maintained and preserved records
9 Development of flexible or sliding scale methods as basis for rates, service and return on investment
10 Adopting for utilities the practice of progressive industry in preserving its physical and economic integrity. Pay down "while the paying is good"
11 An attempt to educate rather than to obstruct or defeat Public Policy.

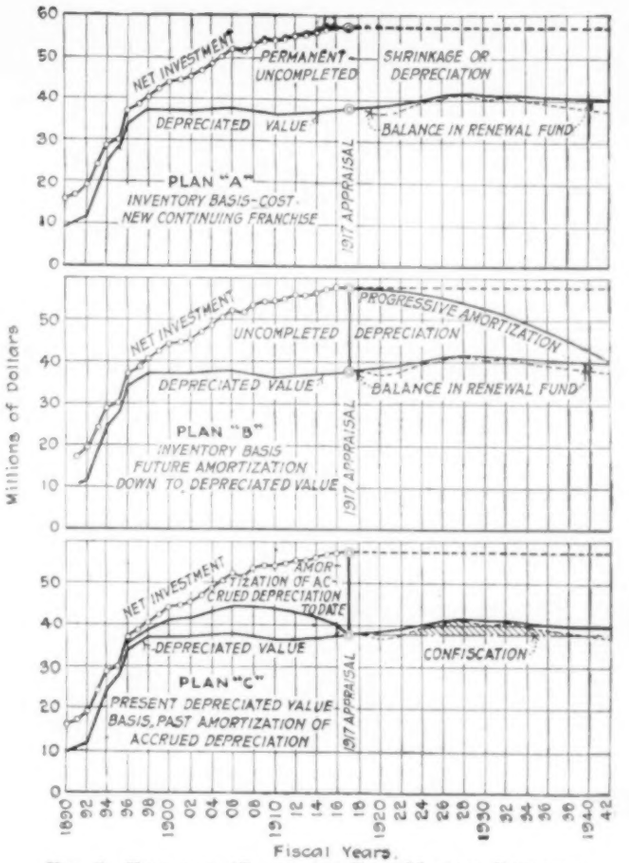

FIG. 5 FINANCIAL PLANS FOR RATE-MAKING PURPOSES

Price Levels in Relation to Value

BY CECIL F. ELMES,[1] CHICAGO, ILL.

IN most rate controversies and appraisals, the opposing engineers are commonly able to agree within very reasonable limits on all purely engineering features. It is when these are set aside and economic questions are broached that sweeping differences appear. Engineers labor faithfully to reach an agreement within twenty thousand dollars on the "bare bones" value of a street railway, or of an electric utility, and then proceed to differ by perhaps two million dollars as to the overhead costs which should be applied to this figure. Their disagreement is not upon engineering but upon economic features, and the results to the public utility business as a whole are so serious that I have no apology to make for devoting myself in what follows to the subject of economics.

Let us start with a precise definition of two of the words in the title of this paper—"Value" and "Price." John Stuart Mill defines the value of a thing as "its general power of purchasing, the command which its possession gives over purchasable commodities in general."

Particular attention is called to the word "general" in this definition. All discussion of value by the great economists is predicated upon the assumption of a free exchange of commodities, with freedom of communication and transport and willing buyers and sellers. The inquiry is never as to the peculiar value of a particular article, such as an heirloom or the last morsel of food among the survivors of a shipwreck. The broad conception of value as set forth by Mill is no more intended for such individual application than an actuary's tables of mortality are intended for use in forecasting the date of a particular individual's death.

The New Standard Dictionary defines "Price" as "The amount demanded by an owner in return for an article as the condition of sale . . . the quantity of labor which its possessor will take in exchange for it."

What relation, in practice, the price demanded by the owner will bear to the value as defined by John Stuart Mill depends upon the circumstances of the case. The likelihood of the two being identical increases, generally speaking, with the available supply of the article, and the readiness with which it may be obtained from any one of a number of sources. The commonness of an article makes it difficult or useless to set an exorbitant price upon it.

In determining the value of any piece of property which is the subject of litigation, courts have always been swayed, and quite properly so, by consideration of the price which the article would fetch if placed upon sale, then and there, under conditions fair to both a willing seller and a willing buyer.

Why Prices Fluctuate

Price, as defined above, can be arrived at in terms of money or of labor. In the economic civilization of today we always quote prices in money. If we possessed an ideal currency not

[1] Sanderson & Porter.

liable to fluctuation in its intrinsic worth, prices of commodities would vary in accordance with the laws of supply and demand, the demand for any commodity tending to cause a rise in its price, and conversely a lack of demand leading to the commodity being offered at a lower price. However, the currency of this and every other country is manufactured out of metals which are themselves commodities subject to the laws of supply and demand and to consequent variations in market price.

Another variable element which must be considered in dealing with fluctuations in market price is foreign exchange, or the ratio at which the currency of one country is traded for the currency of another.

Low Prices

The idea is quite prevalent that we will all be more prosperous when the present high prices give way to lower levels. The fallacy of this hope lies in the fact that lower prices usually result from a lack of demand for commodities, and a lack of demand means a slowing up in commerce, a depression in business, and its result—a lack of employment for labor. Let any one who is clamoring for low prices refer back to such a time as the early 90's of the last century, when commodity prices were at their lowest. The financial panic of 1893 was an effect of prolonged hard times rather than a cause and the charts shown hereafter make it clear that a profound industrial depression overspread the country.

High Prices—Panic or Famine Prices

If low prices, then, are no blessing, high prices in the same way are by no means a curse. In general, they indicate prosperity, of which the times we live in afford abundant proof. In spite of all clamor against high prices, not only are commodities of every kind being eagerly bought, but it is the judgment of retail merchants that the most expensive wares command the readiest market. At no time within the recollection of the present generation have luxuries been more sought, or has their distribution been more widespread.

So long as the free exchange of commodities goes on, high prices are, generally speaking, an indication of prosperity. It is only when the free exchange of commodities comes to a breakdown point that this ceases to be true. The definitions and conceptions of economics are based upon a free exchange of commodities, and they must not be projected into an analysis of the conditions which result when the exchange ceases to be free, or when the ordinary processes of commerce collapse. In such a case we have panic or famine prices. The most common occasions of panic or famine prices are crop failures, the monopolistic act of an individual merchant or group of merchants, or the warlike act of a belligerent in cutting off supplies.

Wages

One of the vital commodities whose price must be considered in any general discussion of price fluctuation is labor. In what follows, labor will frequently be dealt with in terms of the commodities which may be purchased with it. No serious student, however, can afford to treat labor solely as a commodity and wages solely from the standpoint of a price for that commodity.

It is useless to talk about selling a particular article at a price which will not allow a living wage to the workers producing it. As intelligent and progressive citizens, we are forced to postulate a decent living wage in every industry and to regard any commodity price incompatible with this requirement as basically unsound.

Statistics compiled upon the wages of bricklayers in the state of New York, machinists in the state of Pennsylvania, and laborers in the state of Illinois during the last sixty or seventy years, show the first have multiplied by more than four; the second by five; and the third by nearly seven. This relates only to the monetary increase without reference, for the moment, to how much the increased wages will buy.

In view of the fact that labor enters so largely into the cost of every commodity, we have in the foregoing a reason to anticipate a higher level of commodity prices today as compared with the commodity prices of sixty or seventy years ago. The increased efficiency and productiveness of the wage earner will act, of course, as an offset to this. Nevertheless, anyone urging lower commodity prices should first take thought as to how far he is committing himself to a demand for lower wages. And anyone who demands that property be valued today on the basis of what it would have cost to produce it in some bygone year should be ready to squarely meet the issue of whether he is not thereby committed to championing the wages current at that time.

Commodity Price Indexes

In studying the upward or downward movement of commodity prices as a whole, economists have evolved various systems of commodity price index numbers. An index number, applied to commodity prices, is evolved by any one of several methods of averaging actual market prices of the important articles of commerce. A list of basic commodities is selected which the economist regards as being of sufficiently wide range and commercial importance to fairly reflect the commerce of the day. At regular intervals, say every month, an index number is arrived at which is to represent the combined fluctuations of the commodity market. Sometimes the index number is obtained by simply averaging the unit market prices of all the commodities on the selected

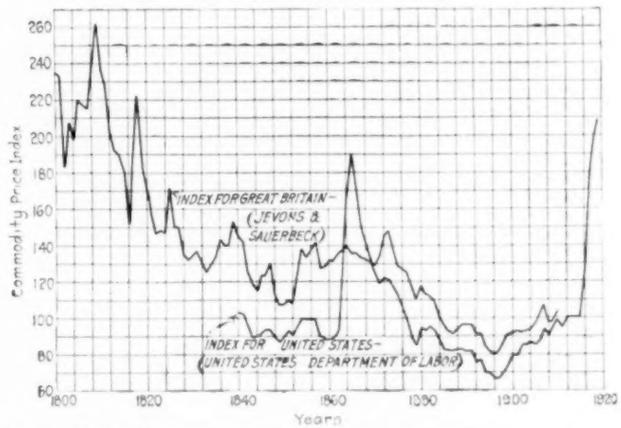

FIG. 1 INDEX NUMBERS OF WHOLESALE COMMODITY PRICES IN THE UNITED STATES AND GREAT BRITAIN IN THE NINETEENTH AND TWENTIETH CENTURIES

list. Sometimes the prices of the individual commodities are weighted to correspond with their relative importance as to: (*a*) quantity consumed; (*b*) vital significance to the life of the community.

There is vastly more iron sold, for instance, than indigo. It would be a criticism against an index number of fluctuations in the indigo market modified it as profoundly as changes in the cost of so basic a commodity as iron. Weight for weight there might be as much paving brick sold as wheat, yet there is no comparison in its importance to human life. An index number which is as largely affected by a change of the market price of paving brick as of wheat is open to criticism. Each commodity price index is therefore largely dependent upon the judgment of the statistician who evolves it and in this way quite a number of commodity price indexes have become current.

Perhaps the most authoritative index in the United States is that published by the Bureau of Labor Statistics of the United States Department of Labor, which will be frequently referred to here. The Bureau has published an index number going back as far as 1860, and in the data compiled for the Aldrich investigation the same index number was carried back as far as 1840. Over 320 commodities are now considered in compiling this index number. Other important index numbers for the United States are those compiled by *Dun's Review* and by Bradstreet; Gibson's index and that of the *Annalist* are also widely used. In England, the London *Economist's* index and that of Sauerbeck are, perhaps, two of the most important. French commodity prices may

be studied from the index number of the *Statistique Générale*.

In Fig. 1 the degree of resemblance will be observed between the index number of the Department of Labor from 1840 to 1919 and the Sauerbeck index for England, the latter being carried back to 1800 by means of tables compiled by W. S. Jevons, the distinguished economist. In this diagram the present practice of the Department of Labor has been followed of using the average commodity price index number for the year 1913 as "100."

The Department's practice in this respect is convenient, inasmuch as it enables us to use the current index numbers as published month by month by the Department to show directly the change in current purchasing power of the dollar as compared with prices prevailing shortly before the war. For instance, the last published number is 226 for the month of August, 1919. That is to say, commodities which could have been purchased for $1.00 during the year 1913 would have cost in August last $2.26.

Analyzing Past Prices and Wages

If we desire to arrive at intelligent conclusions regarding the probable future movements of prices, a careful analysis of past price movements is well worth our while, but at the outset it is necessary to utter a word of caution. Amateur statisticians often attempt to predict the future by literally projecting forward such curves as those in the charts accompanying this paper. Nothing is easier than to take a pencil and ruler and project some of these curves forward into the future. Nothing is more meaningless, or, generally speaking, more misleading. Facts of great value can be obtained from a study of past prices but not by such juvenile proceedings.

The real value of such charts is for the purpose of determining the *underlying causes* of the price changes which occurred in the past. Only when we do this and note their effect can we speculate intelligently on the possible future of commodity markets. There are three groups into which we may divide the factors most profoundly affecting commodity prices:

1 First, the events of contemporary history, wars, revolutions, pestilences and famines. Any study of commodity prices for the last seventy years in the United States which failed to take an account of the Civil War would be a waste of time.

2 Second, the commercial and industrial development of the individual commodities. Any study of brick buildings in England which disregarded the fact that there was a prohibitive tax on brick down to quite a modern period could scarcely have any value.

3 Third, those social and economic movements which have profoundly influenced the welfare of man, without necessarily involving war or revolution. A study of the increase in cost of erecting a brick building which failed to disclose that the wages of bricklayers have in some places multiplied by eight in the last seventy years could not possibly be complete.

[Following this the author takes up these three factors in turn, showing how each in its way has influenced commodity prices. In studying commodity prices in the light of contemporary history, he shows a chart of price indexes in England from the year 1600 to the year 1918 in which are recorded fluctuations due to the great economic and social upheavals occurring during this long period. (Fig. 2.) In relation to the second factor of commercial and industrial development, a study was made of the cost of iron during the 500 years since its discovery, an epoch which the author divides into 12 periods, in each of which there have been economic or industrial conditions which have had a marked influence on the prices of iron.

Finally, in dealing with the third factor, that of economic movements which have influenced the welfare of men, he prepared a chart, reproduced in Fig. 2, in which are plotted the wages of English workmen in certain trades during the 300-year period considered in connection with Fig. 1, in his study of the fluctuation of commodity prices. The chart in Fig. 2 expresses the wages both in dollars per day and in terms of the commodities which might be purchased therewith. "It appears to indicate," the author states, "(*a*) a prolonged period from 1600 on for almost a century, during which the purchasing power of wages was lower than it has ever been since; (*b*) a noteworthy improvement setting in toward the end of the seventeenth century and culminating in the period 1730-1740; (*c*) another long period of depression in the second half of the eighteenth century and extending beyond 1810, practically to the time of the fall of Napoleon; (*d*) a great and continuous upward trend in the buying power of wages culminating about 1900."

Turning to history for an explanation of the causes of the fluctuation of the purchasing power of wages in these several periods, the author attributes the low purchasing power in the first to the state of abject poverty existing in England at that

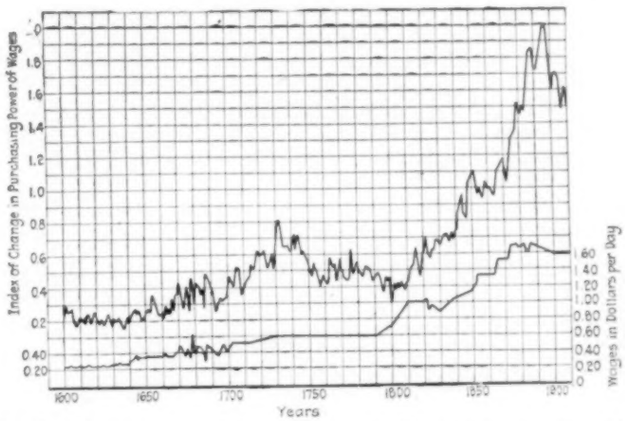

FIG. 2 WAGES OF AN ENGLISH ARTISAN (CARPENTER OR MASON) FROM THE YEAR 1600 TO THE YEAR 1918

time—a period when it is estimated there were paupers and beggars to the number of 1,333,000, or more than one in five of the population. Following this came the adoption of sound currency and an improvement in conditions until the third period,

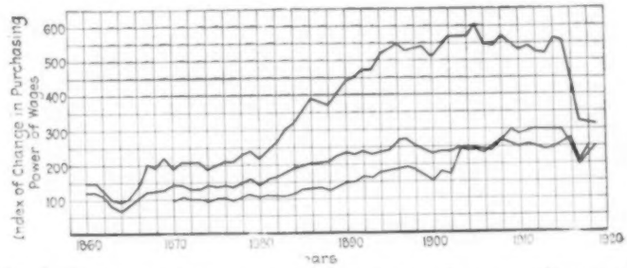

FIG. 3 RELATIVE CHANGE IN THE PURCHASING POWER OF WAGES OF CERTAIN CLASSES OF WAGE EARNERS IN THE UNITED STATES FROM THE YEAR 1860 TO THE YEAR 1920

that of the Seven Years' War, and the development under the German kings of England of a tyrannous government which led to the Revolution. During that period the factory system was in full swing with an oppressive system and unhealthy conditions prevailing, a day's work consisting of 15 or 16 hours and young children regularly working in the mills 14 hours a day. The fourth and last period covers the improvement of the status of the workingman which is one of the great features of the nineteenth century.]

American Wages in the Light of Commodity Prices

Turning to modern American wages, compared with the corresponding commodity prices, as plotted in Fig. 3, conditions are in striking contrast to the grim picture presented in former times in the history of English labor. The unit or index employed to measure the relative change in the purchasing power of a workingman's day's labor is not important. It is the rate of change in this index which is significant, the fluctuation in the purchasing power of his day's work from year to year. If that is ascending, it is fair to assume that his conditions are im-

proved. If it shows a steady decline, it is reasonable to suspect that his conditions are becoming worse. The reader must be cautioned in regard to peak or high points. While apparently indicating prosperity to the individual artisan in continuous employment, they take no account of the fact that the bulk of unemployment may be great and actual distress is the result.

No claim is made that the curves in Fig. 3 are in any way complete for the purpose of such a study of the labor situation. That is not the primary purpose of this paper. Nevertheless, even with the small amount of data here presented, it will be noted how the workingman's conditions have improved, even allowing for the fact that the curves in Fig. 3 do not show to the full many recent wage increases. Taking Fig. 3 as it stands, however, labor today appears to have increased its purchasing power over conditions in, say, 1870 in a ratio of roughly fifteen to thirty. That is, the purchasing power of a man's working day yields approximately twice as much in commodities as it did in 1870. The standard of living of the workingman has greatly improved. This is a highly desirable condition. Without a doubt this country as a whole has greatly benefited from raising the living standard of the wage earning portion of the population. Further, no one will claim today that a lack of demand for labor is to be reckoned as nullifying the improvement in buying power of the wages an artisan receives.

PREDICTING THE FUTURE COURSE OF PRICES

I have emphasized the fact that any efforts to predict future prices by projecting forward from a curve or graph of former prices by means of a ruler are foolish. Nevertheless, the inquiry as to what may be anticipated in the future will always be raised, and we are thoroughly entitled to use our best judgment in hazarding a prediction.

A guess as to the future price of an individual commodity must necessarily allow for progress and invention in that particular industry. A guess as to the future movements of commerce as a whole must be based upon some reasonable assumptions as to the general direction of human and economic progress. Great historical events, such as wars and revolutions, may be expected to produce big effects in the future, as in the past, but we are practically unable to predict them at all, and therefore cannot make allowance for them in future prices. Setting such greater disturbances aside, we may still do something towards forecasting future prices in the light of events of today.

The predominant element in making up the price of any commodity today is labor. Therefore, if any man claims that prices are to come down, without at the same time predicting great advances in the way of invention to increase the efficiency of labor, he is really arguing that the price of labor also is coming down. Any prophets who forecast lower commodity prices in the near future (particularly some of those whose prophecies are used as a basis for making rates on public utilities) should be forced to admit that they are in effect taking future lower wages for granted and when they do this they must be made to recognize that the burden of proof of any such claim is upon themselves.

RELATION OF COMMODITY PRICES TO PUBLIC UTILITIES

At first sight it might seem unnecessary to call attention to the relation of public utilities to the prevailing commodity prices of today. It ought to be self-evident. The public-utility man is just as much a merchant as any other merchant. How can he fail to be affected by conditions that affect every living human being? And yet, the events of the past two or three years, in fact events of the last decade, show that this apparently self-evident fact is not evident at all to a large section of the public. An immense number of people seem to be educated to the idea that the butcher, baker, and candlestick maker are all living with them in the year 1919, but public utilities, in some mysterious way, are expected to live half in the present and half in the pre-war past. A dollar bill handed to them for the payment of a 1919 electric-light bill is to be able to transact as much business for them, to purchase as much raw materials and labor as it could have done in, say, the year 1913—although it is fully recognized that it has no such occult power in the hands of the customer who tenders it to them.

I will hazard a guess that future generations may look back with curiosity to some of the practices now in use in valuing railroad property throughout the country. As fast as a railroad completes construction today, with labor and materials purchased and erected today, paid for at the prices of today, the rate-making body proceeds to place a "valuation" upon the newly completed construction work based not on what it actually cost, not on what any living human being could do it for today, but on the assumption that a magician built the work with labor and materials called up out of the past at the prices current on June 30, 1914. Whatever legitmate use a "valuation" of the railroads of the country "as of June 30, 1914" may be thought to have, it would surely seem that this order of "theorizing" a value constitutes nothing less than a perversion of economic thought.

SETTING A PRICE ON THE SERVICE OF A PUBLIC UTILITY

Assuming then, the prices we find actually prevailing in the market today, how shall we set a price upon the service of a public utility? Exactly as we determine the price of any other merchandise. What shall we pay for it? We should pay for it what the service is worth. How shall the worth be measured? In terms of the currency used to pay for it. If the service was

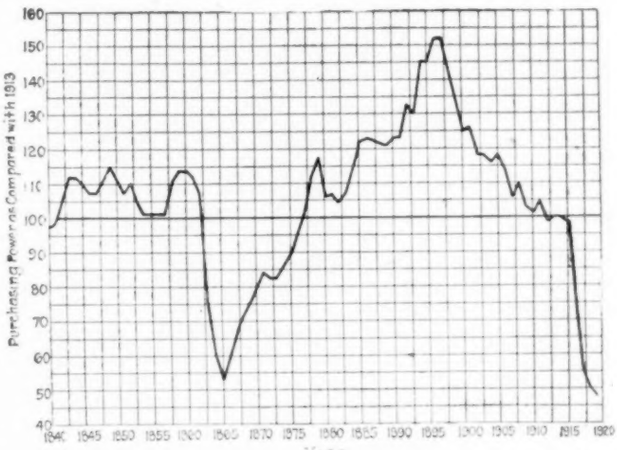

FIG. 4 FLUCTUATION IN WHOLESALE COMMODITY PURCHASING POWER OF THE DOLLAR FROM THE YEAR 1840 TO THE YEAR 1919

worth $100 in 1913, and if $226 in August, 1919, will buy as much of commodities in general as $100 bought in 1913, then public utility service (or any other service) that was worth $100 in 1913 is, *ceteris paribus*, worth $226 today.

Any one conversant with the way in which public utility rates are determined today will know that no such thought is ever entertained. On the contrary, elaborate property valuations are prepared, based sometimes on what the property would have cost if built at some other and more remote period, sometimes based upon no price that ever was. Prices are often used in valuation of public utilities, as many of you know, based on a trend curve, whose author takes the position that while the prices of a certain date were, in fact, what every one knows them to have been, they really ought to have been something else. The record of rate cases in the last two years is full of instances where nobody in the entire proceeding discussed anything in terms of the market prices then actually prevailing and being paid by every individual present at the rate hearing for every commodity necessary to keep himself alive.

HOW RATE PROCEEDINGS SHOULD BE INFLUENCED BY CURRENT COMMODITY PRICES

Am I, then, to be understood as suggesting that all pre-war valuations be abandoned and only valuations as of the present day be employed? I have been asked this question frequently in the last six months, and the answer to it is that I am not much interested what basis is used for valuing a company's property and for setting up the facts relating thereto so long as both the company and its customers get equal treatment. But if a rate-

making body is to carry on its work using the word "dollar" in the same rate case to mean two different things, to mean a dollar of high purchasing power every time one party to the controversy is mentioned, and a dollar of low purchasing power every time the opposing party is mentioned, then there is an elemental injustice present in the proceeding. Can it be claimed as fair that a dollar should have the purchasing power of 1913 ascribed to it whenever a public-utility company's property is being evaluated in dollars, while all parties are fully aware that rates can only be paid in the dollar of today with its vastly different purchasing power?

The investor in a public utility is already severely enough injured by the change in purchasing power of the dollar. To a vast extent his investment has been made out of savings effected in times when the dollar was the fruit of far more labor and material than it is today. One thousand dollars invested in the public-utility business ten years ago represents a much greater amount of labor and a much greater amount of thrift than a corresponding thousand dollars invested today. More of a man's life and toil went into it.

The United States Department of Labor commodity price index, as shown in Fig. 1, puts the figures of the situation in their fair relation. The labor and frugality which will produce 226 dollars today produced only 100 dollars six or seven years ago. We may not be able to remedy this situation; it may be inherent in our economic and financial system, and may be part of the burden that the investor must bear. But there certainly is no use in denying it or covering it up, and certainly none in talking as if the burden and hardship did not exist.

In Fig. 4, in which I have expressed the United States Department of Labor's commodity price index in terms of the shrinking purchasing power of the dollar, I have followed the Department's lead in using the index for 1913 as a base point, calling it 100 cents on the dollar. It will be noted that the purchasing power of each of the six or seven or eight dollars which the investor of 1913 looked to as the income to be derived from each hundred of his savings has shrunk today until each dollar can accomplish only what 44 cents accomplished at the time he made his investment. The chart shows how severely he has been hit.

The Cost of Organizing and Financing a Public-Utility Project

By F. B. H. PAINE[1]

Introduction

HAVING been associated with the late Mr. Paine on important work, and being familiar with his views based on his investigations into somewhat unusual phases of public-utility valuation, it has occurred to me that wider publicity should be given his views than has resulted from his expression of them in reports and before utility commissions. The following paper by him was prepared in July, 1916. It was in fact a report on a particular property. In order to adapt it to the requirements in the present instance I have made a few changes—those which make it read for the general rather than a particular case. No changes in substance have been made. Mr. Paine was an unusual man. His wide experience along the lines of his paper particularly qualified him to express the views set forth. In discussion of them he was most forceful and convincing. It affords me great pleasure to render this service to the memory of so talented a man, so modest and unassuming, and so good a friend. His work ceased just at the time when it had come to fruition.

M. E. Cooley.

BEFORE the construction of the physical property of a utility can be begun, even before the engineering and other plans for that physical property are begun, there are certain preliminary steps necessary to be taken which involve much effort, time, and expense, and which are incurred at much risk of entire loss before the project as a whole can be said to be finally launched. These steps embrace the company's rights from the public, arrangements for the necessary capital funds with which to reimburse itself for preliminary outlays, and funds with which to construct the physical property necessary to fulfill obligations to the public incurred and incident to its rights to conduct a public-utility business.

I will outline these preliminary and necessary steps, state their reasonable costs, and the basis of my estimates. Each indicated percentage, or their sum, should be applied to the total direct and indirect construction cost, including administration and law expenditures, interest, and taxes during construction. I have placed them in three groups:

A—The Development of the Project.....	2½ per cent
B—The Cost of Money.....	5 per cent
C—The Promoter's Remuneration.....	5 per cent

Inasmuch as the preliminary effort, time and expense, the cost of money and the promoter's just remuneration vary proportionately with the breadth, the scope, and particularly the magnitude of the property, they may most conveniently be expressed as percentages of the cost of producing a new property or the estimated cost of reproducing an old property. These three groups are as absolutely essential to the service of the public as the physical groups themselves. Indeed, the latter are only made possible by the former.

[1] Deceased.

A—The Development of the Project

The items listed below are intended to show in barest outline, by headings, the nature of the preliminary problem. It is not intended to list specifically each and every feature detail, nor can I possibly estimate in detail what each item has or would reasonably cost because the items are all so interrelated and interdependent that no sharp line can be drawn between them. We can, however, estimate upon the cost of this group as a whole, with reasonable accuracy.

1 Conception of the project
2 Determination of its scope and territorial breadth
3 Preliminary outline design and preliminary estimates of cost
4 Estimates of operating expenditures, of operating revenue and resulting profits
5 Prospectus or description of the project
6 Development of the financial plan
7 Legal and other advice
8 Negotiations with bankers and underwriters for capital funds
9 Negotiations with state and community governmental bodies necessary to secure the state charter, franchises, and the approval of the franchises, prospectus and financial plan by the Board of Public Utility Commissioners, and other such matters; but not including any payments to the public for the public rights, nor including any valuation of those public rights.

The old accounting systems were never kept in sufficient detail to show the costs of this group, which I call "Development of the Project." In recent years, however, there have been instances where such costs are approximately known, and there have been many estimates and allowances made by commissions and courts. The percentage allowed on the cost of physical property has, as a rule, fallen within the range of from 2 to 4 per cent, according to the size of the property and state requirements.

The first question, therefore, is how reasonably to estimate the cost of these preliminary requirements as if they were to be incurred as of the present day with the construction of a great public-utility system in view. The necessity for the preliminary work and studies is patent to anybody; the law of the state makes them absolutely essential. That they will cost a great sum of money is obvious; and equally so that the amount involved will be approximately proportional to the magnitude of the project. At this stage of consideration the property being ap-

praised must be looked at as a project; it cannot become a reality until after the preliminary steps have been taken.

The work involved in the development of the project is performed by the same type of men as are concerned subsequently in the administration of the construction of the property and later in its operations. From general experience we know that the effort and time involved would at least quite equal that incident to the physical construction of the projected utility; and it may be fairly assumed that the expenditures involved in the development of the project would be substantially equal to the cost of the administration and legal expenses during construction. Therefore I have so estimated it.

It costs about the same to administer the expenditure of a million dollars properly, for whatever purpose the money be spent. If during a year the expenditures of a utility corporation for operations and for new property amount, say, to ten million dollars, and if in the same year the administration and legal advice costs $250,000, or 2½ per cent of the money expended, that percentage may reasonably be taken to represent the cost of administration and legal advice during the construction of the property; and it may also be taken to represent the cost of the development of the project, for the reasons given in the preceding paragraph. I have found from a study of public-utility companies' accounts that at least 2½ per cent of the money spent for operating and for construction was the cost for administration and legal expenses, as I am here using these terms.

This method of estimating the costs of development of the project would only fall into error where there are some peculiar or unusual conditions, as in a particular state. In some states there are certain conditions which make for a lesser cost of securing the public rights, gaining approval of them and of the financial and other plans; and in other states the public requirements are such as to increase these costs. In some states, for some kinds of utilities, no local franchises are necessary; in other states there is still no controlling body like public utility commissions. Where there is no occasion to obtain approval of any local franchises, or of any project with its prospectus and financial plan, the preliminary costs are correspondingly less. But where separate charters, corporations, and other forms are necessary in each political subdivision of the state, and the necessity exists for securing approval of the controlling body, for each subdivision, the preliminary costs are correspondingly more.

B—Cost of Money

In order that money may be secured for a particular enterprise, such as a public utility, there must be a cost incident to its acquisition; not only a cost incident to the acquisition of the first money needed, but for each enlargement of the property. This is always true of every such enterprise and always will be. This cost of money is sometimes, in fact, is usually, merged in and becomes a part of what is generally termed "discount" on such bonds and stocks as are sold.

I am here referring only to that part of discount which is incident to the expense of procuring the money with which to construct. The corporation might sell its securities "over the counter," which would involve an expense, or they might employ agents for the disposition of their securities (employing the word "security" to include stocks, notes, etc., as well as first-mortgage bonds), commonly known as brokers, underwriters, bankers, etc.

When we wish to rent or sell real estate we employ a real-estate agent to do it for us because that is his business and he can do it and make a profit at a less cost, or to better advantage, than we could ourselves. There is a cost in either case attendant upon each such transaction, i.e., the value of our own time and effort taken from our own ordinary occupation versus the payment of money to an agent whose ordinary business it is.

Funds with which to construct a property of any considerable magnitude are invariably and necessarily secured from the world's money markets. No locality, or no one market, would be sufficient for the needs of a large enterprise. Funds from these world money markets are invariably supplied through bankers or underwriters, who for themselves make an investigation of the property from the engineering, legal, and commercial points of view. They must bear this expense as well as the expense of selling to the ultimate buyer. They must also assume the risk of changes in the financial situation, or of error in judgment as to the salability of the securities and the price that they will command at such times as the corporation needs the funds. Not infrequently the banker or underwriter is compelled to carry issued securities of a high-grade character for long periods, while the utility gets its money as needed. The public's demand for service cannot be denied whether the money market is favorable or unfavorable. The practical necessities of the case make it wise for a utility company to secure its funds through agents or underwriters who assume the burden of the risks and the expense of reaching the widest, greatest world's money markets. The cost of money is by no means "velvet" to the banker or others who underwrite an "issue."

During the past two years I have been under the necessity, and have had the opportunity and facilities, of informing myself as to the cost of acquiring money in the case of sixteen large and well-known utility companies, with nineteen issues of the highest grade bonds, rated in Moody's Analysis of Public Utilities as "AA" or "A," and marketed within the period from 1908 to 1914. The result of my investigations was to find that the cost incident to the disposition of the senior ("AA" or "A") highest rated securities of these large, well-known utilities was 5 per cent; the discounts were much more than that. The cost incident to selling bonds rated by Moody as "BA" and "BAA," found in the same manner, was 7.9 per cent.

The propriety of allowing this item as one of the proper elements entering into the fair value of a utility has been favorably passed upon by commissions and courts in this country, but the clearest and most complete analysis is that of the English Justice Lawrence in the Railway and Canal Commission, Royal Courts of Justice, in the condemnation case of the National Telephone Company, Limited, vs. His Majesty's Postmaster General. This covers the questions so completely that I quote from that part of the decision dealing with the cost of money.

> The first question then is, would it, in fact, cost anything to provide the necessary capital? The Company have given evidence by way of example, that it cost them 4.41 per cent to raise 5 1-2 million pounds. No one has given evidence that it would not cost anything, nor has that proposition been put forward even in an argument. I know of no commodity and of no service that can be procured as of right for nothing.
>
> It has been said that it cannot be an element adding to the value of the plant. The thing transferred here is the plant "in situ," and the cost of construction, less depreciation, is the method by which the value has to be ascertained. It follows that every expense which is necessary in order to construct is an element to be considered, and it has to be considered because it is necessary in the process of construction. The thing to be transferred, say a pole, must be procured, transported, and erected; each of these steps is necessary to the existence of the pole "in situ"; each of these steps cost money, and raising this money is itself an expense and is one as necessary to the existence of the pole as any of the other steps.
>
> *The cost to be considered is the cost to the hypothetical constructor who is a person in good credit*, or, in other words, what it must cost any constructor. This does not involve the conclusion that the cost of raising capital should be added to the price again if the property should be transferred a second or a third time; it is an item of value once and once only, namely on the construction of the plant, and it is merely because it is necessary in order to construct that this item comes into the calculation at all. That it must be included is apparent, if it is tested in a case in which the sale takes place immediately upon the completion of the construction.

I call special attention to the sentence italicized by me: *The cost to be considered is the cost to the hypothetical constructor who is a person in good credit.* With this part of the decision I personally do not agree when applied to establishing a fair value for another company differently situated. The Board of Public Utility Commissioners does not deal in condemnation or confiscatory matters, but does deal in matters establishing a fair value, among others. "Fair" means more than that which just avoids being confiscatory.

It is obvious that the cost of money is greater on that part of the capital raised on the junior securities than on the senior securities; greater for small undertakings less well situated with respect to the money markets than for large properties very well

situated; greater for securities of any class of low rating, than for those of the very highest rating. It does not seem fair to me, therefore, that the allowed cost of the money with which to construct should in all cases be only that allowed in the most favorable circumstances. It follows in my judgment that the fair cost of money necessarily raised for a new enterprise, or for a utility whose securities are not of the highest standing, would be more than 5 per cent—as high as 7.9 per cent. That is the percentage which I found it had cost to sell bonds rated by Moody as "BA" and "BAA."

Securities issued by a corporation under a general mortgage are often classed as "Collateral Trust Bonds." They represent fairly the average, or the mean, of the credit attaching to the various senior and junior security issues of such a corporation necessarily issued to raise all the money needed to construct the whole property. The highest-grade first-mortgage bonds rated in the "A" group by Moody probably could not be sold in amount more than 60 per cent of the total money required. The remaining 40 per cent would have to be acquired through the issue of other forms of junior securities such as common and preferred stocks, second-mortgage bonds and collateral-trust bonds or notes. It costs less to sell the former than it does the latter for the reason that the first mortgage for a limited amount relative to the size of the property has a higher credit than the junior securities. A first-mortgage bond such as I have described absorbs in addition to its own proportion of the corporate credit, all the credit underlying the junior securities as well, and leaves all the risk of the business upon the shoulders of the junior securities in varying degrees according to their degree of juniority. Therefore, when the cost of money with which to construct the whole property is taken as that which it would cost to sell only 60 per cent of the most precious, most easily sold part of the securities, it in my judgment amounts to confiscation of a part of the cost of money involved in raising the rest of the necessary capital funds. That is why I think that usually the fair amount to allow would be more than 5 per cent and might easily be 7.9 per cent of the cost of the property devoted to the public use.

However, under the most liberal interpretation of the phraseology of Mr. Justice Lawrence's decision in the condemnation case referred to, it is the cost of money with the best of credit which is to be considered; therefore, the measure I adopt as the "cost of money" with securities rated "BA" or "BAA," is the cost of capital funds secured for utilities of the highest credit, best salability, such as first-mortgage monds rated "AA" or "A." I take this as the measure in order that my estimate may be regarded as ultraconservative, that it may be accepted as the very minimum.

I arrive at 5 per cent as the cost of money in the following manner: Let us assume that the securities are sold at less than par, or less than their face value. A part of the difference from par is due to the cost of obtaining the money. This part, as I have shown, belongs to the cost of construction and is therefore proper to capitalize. The remaining part is an interest adjustment necessarily made to satisfy the money markets at the moment of sale, which is true discount and may not be a proper capital charge.

Whatever the interest adjustment, whether discount or premium, it is easily determinable as it is the amount less or more than par, or face value, at which the securities are taken by the general public or ultimate purchaser. The cost of money is the difference between the price paid by the ultimate purchaser and the net amount received into the "till" of the corporation. If securities are sold to the ultimate purchaser at above par it simply means that the par, or face interest, is higher than necessary to satisfy the money market. The same security is sold sometimes above par and sometimes below par, according to the demands of the money market at the moment of sale. Money is a commodity which varies in its market requirements much as wheat and other commodities vary. The cost of money, however, is distinct from discount or premium and is the difference between that paid by the ultimate purchaser and the amount received into the corporation till.

As it is the cost of raising all the money which it would take to construct at the present time, the per cent of the cost of money is to be applied to the entire estimated cost of construction. Generally speaking, the money with which to construct is secured through the sale of various kinds of securities—common stock, preferred stock, second-mortgage bonds and notes, as well as first-mortgage bonds. Let us assume three examples:

Example 1:

Par value of bond	$1000
Interest, per cent	5
Bond sold to ultimate purchaser for	975
Net amount received into corporation till	925
In such a case the cost of the money would be the difference between $925 and $975, viz., 5 per cent, which is properly capitalized	50
The interest adjustment required by the money market would be a discount of 2 1-2 per cent	25

Example 2:

Par value of bond	$1000
Interest, per cent	5
Bond sold to ultimate purchaser for	1030
Net amount received into corporation till	980
In this case the cost of the money would be as in the first example, 5 per cent, properly capitalized	50
The interest adjustment required by the money market would be a premium of 3 per cent	30

Example 3:

Par value of bond	$1000
Interest, per cent	4
Bond sold to ultimate purchaser for	800
Net amount received into the corporation till	750
Here again the cost of money properly to be capitalized would be 5 per cent	50
The interest adjustment required by the money market would be a discount of 20 per cent to adjust the assumed market requirement of 5 per cent interest	200

In arriving at my conclusions as to the cost of money I first took the per cent cost incurred in the sale of each of the 19 issues rated at "AA" or "A" of the 16 corporations and found that by adding together the per cent costs and dividing the sum by the number of issues the true average cost was 5.1 per cent. I then multiplied the par value of each issue sold by the per cent cost incurred in that particular sale which gave me the cost in dollars for each case; and by adding all these together I found it had cost $3,164,000 to market $64,845,000 par value of bonds, or 4.9 per cent; 5.1 per cent being the average of the percentages; 4.9 per cent being the weighted average. I took the mean, or 5 per cent, as representing the cost of obtaining money. I found in a similar way that the cost of marketing the "B" group of bonds was 7.9 per cent.

C—Promoter's Remuneration

"I know of no commodity and of no service that can be secured, as of right, for nothing."—Mr. Justice Lawrence. What is it which would induce any promoter or any group of persons to make such a preliminary expenditure as I have described under "development of the project" and then provide the money and assume the two great risks: First, that the project would fall by the wayside and never come to fruition at all; second, its failure afterward? Why should the promoter render such a service as has been rendered to the public in providing most existing utilities? The answer is: Remuneration for service rendered. Promoter's remuneration, as dealt with here, is the cost to the public for the promoter's services. It is entirely distinct from the cost of the preliminary development of the project and the cost of securing the money with which to build the property.

There must be some inducement to bring about the activities of the promoter in the particular enterprise, and that inducement is profit or gain; and for it he renders a valuable service. The service of the promoter is essential at all stages of the utilities' development, not only in the beginning, but with the addition of each increment of capital needed for enlargement or extensions. Enterprise without the service of a promoter is inconceivable. The Railroad Securities Commission appointed by President Taft, of which Arthur T. Hadley, President of Yale University, was Chairman, said on page 30 of their report.

We are told that the profit of the promoter represents a wholly unnecessary burden upon the American public, and that so far as this

profit can be done away with it will be good for all parties. Neither of these statements is quite true. The promoters, using the term in a broad sense, may be divided into two classes: constructors who build a railroad whose future is uncertain, in the expectation of selling the stock for more than it cost them; and financiers who induce the public to buy the bonds of such roads. Both of these classes, if they do their work honestly, render useful service to the public. The constructor gives our undeveloped districts the benefit of new roads, which they would not get without his intervention; and if he does his business well he builds the road more economically than anybody else could. The financier renders an equally important service in collecting the capital of the investors to build new railroads or improve old ones.

There are many similar statements made by commissions, courts, and other authorities, and I think all commissions have recognized that the services of a promoter should be properly remunerated.

When a public-service commission is determining the fair value of a property, it should make no difference whether the property is old and has been rendering a valuable service, or whether it is new and much desired by the public; the same elements should enter into the value on which earnings are allowed; and whatever is a proper allowance necessary to induce new and valuable enterprise must also be a proper allowance to give the promoters of an enterprise already in existence and of undoubted public use and in which the risk has been incurred and the service rendered.

The service of a promoter having been essential to a particular utility, the property having been built and having rendered a valuable service to the community, it is entirely proper that a reasonable recompense should be made on account of the service of promotion. The fact that the promoter might be the present owner does not in any way affect the equity. If now, when the state for the first time fixes the value and exercises control over the property, it denies remuneration to the promoter an injustice will be done. The promoter, indeed, might better have gone elsewhere.

In the application of the Rochester, Corning and Elmira Traction Company for consent to the execution of a mortgage, and authorizing the issuance of capital stock, the Public Service Commission of the State of New York, 2d District (opinion by Chairman Stevens, in Vol. 1 of the report of April 1, 1909, p. 166), dealt with the whole subject very fully (as it has been by many other commissions) and allowed 5 per cent as promoter's remuneration. It has also allowed 5 per cent in the case of other projected utilities.

In the decision by Chairman Stevens, in the case referred to, he speaks of the difficulty of determining the exact amount which the promoter should be paid under the varying conditions. He fixed 5 per cent for a proposed railroad, the desirability of which he had passed upon favorably. My judgment is that his allowance was too small for such a new project (the road was not built), yet he is a man intentionally fair, of good judgment, and has had good opportunities for observation. Five per cent has been accepted in other cases and is a frequent minimum provision in promoting large enterprises. Therefore, it follows, and my judgment is, that five per cent of the cost of a property is the minimum proper capital allowance which should be made, in the appraisal of public utilities

The Construction Period

By H. C. ANDERSON,[1] ANN ARBOR, MICH.

IN the early days of appraisals, the item of interest during the construction period was frequently ignored. In some of the later appraisals it has been taken at very large figures, large because of the assumption that the construction period extended to the completion of the entire property; that is, no part of it was assumed to go into operation before the completion of the whole. There seems to be very little, if any, disagreement among engineers and commissions as to the annual rate of interest, but in many cases there is a wide variation in the length of the construction period.

If it is assumed the property is to be reproduced "piece-meal" we will have one period of construction. On the other hand, if the property is to be reproduced "wholesale" we will have a different period of construction. If a certain property is to be reproduced "piece-meal" the result would naturally be higher unit cost and lower total interest cost than if reproduced by the "wholesale" method. In some cases the two may balance.

The particular part is to fix, as accurately as possible, the duration of the construction period. Usually some part of the property, a power plant for instance, will be the best guide. Obviously, a street railway, complete in every other respect, must remain idle without power.

The question of the critical speed of construction must be given consideration. Theoretically, a large property could be constructed in a few months, assuming enough men and material could be procured; but to do this it would be necessary to exceed the speed of economical construction, which would result in a very high unit cost, and no doubt would more than offset the decrease in the interest cost. Consideration, also, must be given to the question of obtaining labor and material in large quantities at the time desired, and the fact that no city would consent to the extensive tearing up of its streets that might be necessary with a short period of construction.

One method often used is to assume an interest rate of 6 per cent applied to the entire cost over one-half the construction period. The cost is zero at the beginning and is assumed to increase uniformly to the full amount at the end. A criticism of this method is that money cannot be borrowed day by day, or month by month, as needed. It is difficult to imagine bankers willing to furnish money in this way.

Another method often used is to assume an interest rate of 6 per cent and 2 per cent allowance on the unexpended balance, assuming the unexpended balance to equal one-half the loan, and the loans to be made at equal intervals during the construction period. The following concrete problems will illustrate the two methods.

PROBLEM NO. 1:

Assume a property costing $12,000,000 and a construction period of three years, interest rate 6 per cent. The expenditures proceeding uniformly from zero at the beginning to the full amount at the end.

Solution:

Six per cent for one-half the construction period will give a total interest charge of 9 per cent, this applied to the $12,000,000 cost will give $1,080,000 as the interest cost.

$$\frac{1{,}080{,}000}{12{,}000{,}000} = 9 \text{ per cent}$$

PROBLEM NO. 2:

Assume a property costing $12,000,000 and a construction period of three years, interest rate 6 per cent, allowance on balance at the rate of 2 per cent, balances equal one-half the loan. $2,000,000 borrowed each six months.

Solution:

First loan	$2,000,000 @ 6% for 3 yr.	$360,000	
Credit on balance...	1,000,000 @ 2% for ½ yr.	10,000	
Net interest first loan.....			$350,000
Second loan	2,000,000 @ 6% for 2½ yr.	300,000	
Credit on balance...	1,000,000 @ 2% for ½ yr.	10,000	
Net interest second loan.....			290,000
Third loan	2,000,000 @ 6% for 2 yr.	240,000	
Credit on balance...	1,000,000 @ 2% for ½ yr.	10,000	
Net interest third loan.....			230,000

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Fourth loan	2,000,000 @ 6% for 1½ yr.	180,000	
Credit on balance...	1,000,000 @ 2% for ½ yr.	10,000	
Net interest fourth loan.....			170,000
Fifth loan	2,000,000 @ 6% for 1 yr.	120,000	
Credit on balance...	1,000,000 @ 2% for ½ yr.	10,000	
Net interest fifth loan.....			110,000
Sixth loan	2,000,000 @ 6% for ½ yr.	60,000	
Credit on balance...	1,000,000 @ 2% for ½ yr.	10,000	
Net interest sixth loan.....			50,000
Total interest for three years.....			$1,200,000

$$\frac{12,000,000}{1,200,000} = 10 \text{ per cent}$$

If this money is borrowed $4,000,000 each year for three years instead of $2,000,000 each six months the total interest becomes

$$\frac{1,320,000}{12,000,000} = 11 \text{ per cent}$$

It will be noted, in this analysis, the assumption is made that no part of the money is spent until the day construction starts. In actual practice this would be very difficult, if not impossible. The land for various purposes, such as right of way, power stations, sub-stations, shops, car houses, gas plants, commercial offices, etc., would necessarily have to be purchased one or more years before construction started. The following concrete problem will illustrate this method.

PROBLEM NO. 3:

Assume a property costing $12,000,000. Of this amount the cost of land is $1,200,000 and the structural property $10,800,000. It will require three years to obtain the land, starting one year in advance of construction. Construction period of three years. Interest rate of 6 per cent, allowance on balance at the rate of 2 per cent, balances equal one-half the loan, money borrowed each six months.

Solution:

If the purchase of land starts one year in advance, and money is borrowed every six months there will be 8 periods to consider; following are the amounts borrowed each period.

	Land	Structural Property	Total
First Period	200,000	.....	$ 200,000
Second Period	200,000	.....	200,000
Third Period	200,000	$1,800,000	2,000,000
Fourth Period	200,000	1,800,000	2,000,000
Fifth Period	200,000	1,800,000	2,000,000
Sixth Period	.....	1,800,000	2,000,000
Seventh Period	$200,000	1,800,000	1,800,000
Eighth Period	.....	1,800,000	1,800,000
Total	$1,200,000	$10,800,000	$12,000,000

First loan	$200,000 @ 6% for 4 yr.	$48,000	
Credit on balance..	100,000 @ 2% for ½ yr.	1,000	
Net interest second loan.....			$47,000
Second loan	200,000 @ 6% for 3½ yr.	42,000	
Credit on balance..	100,000 @ 2% for ½ yr.	1,000	
Net interest second loan.....			41,000
Third loan	2,000,000 @ 6% for 3 yr.	360,000	
Credit on balance..	1,000,000 @ 2% for ½ yr.	10,000	
Net interest third loan.....			350,000
Fourth loan	2,000,000 @ 6% for 2½ yr.	300,000	
Credit on balance..	1,000,000 @ 2% for ½ yr.	10,000	
Net interest fourth loan			290,000
Fifth loan	2,000,000 @ 6% for 2 yr.	240,000	
Credit on balance..	1,000,000 @ 2% for ½ yr.	10,000	
Net interest fifth loan.....			230,000
Sixth loan	2,000,000 @ 6% for 1½ yr.	180,000	
Credit on balance..	1,000,000 @ 2% for ½ yr.	10,000	
Net interest sixth loan.....			170,000
Seventh loan	1,800,000 @ 6% for 1 yr.	108,000	
Credit on balance..	900,000 @ 2% for ½ yr.	9,000	
Net interest seventh loan.....			99,000
Eighth loan	1,800,000 @ 6% for ½ yr.	54,000	
Credit on balance ..	900,000 @ 2% for ½ yr.	9,000	
Net interest eighth loan.....			45,000
Total interest cost			$1,272,000

$$\frac{1,272,000}{12,000,000} = 10.60 \text{ per cent}$$

If this money is borrowed at the beginning of each year instead of every six months the amounts for each period will be as follows:

	Land	Structural Property	Total
First Period	$400,000	.....	$ 400,000
Second Period	400,000	$3,600,000	4,000,000
Third Period	400,000	3,600,000	4,000,000
Fourth Period	.....	3,600,000	3,600,000
Total	$1,200,000	$10,800,000	$12,000,000

The total interest cost will be $1,392,000.

$$\frac{1,392,000}{12,000,000} = 11.60 \text{ per cent}$$

I do not know of any one formula that can be applied to every type of utility, and which, when solved, will give accurately the interest cost during construction. Each property will have its own individual problems, and for this reason a thorough study should be made of the particular property under consideration to determine:

1 The magnitude of the property and the difficulties that must be overcome during construction
2 The method used in finding the reproduction cost
3 The proper construction period, taking into consideration the method used in finding the reproduction cost
4 Knowing the construction period, what is the proper method to use in finding the total interest cost?

In the end, after all theories have been considered. it is the judgment of competent engineers that should be the controlling factor.

TAXES DURING CONSTRUCTION

Like interest, taxes during construction is an item of cost incurred during the construction period and must be paid, the only question being, what is the proper amount to allow. It may be argued that the value of a utility depends on its earnings, and there can be no earnings during the construction period, therefore no taxes should be paid. But it does not work that way. The assessor finds the land and puts it on the rolls. He finds the building materials, machinery, and partially erected buildings and they also go on the rolls, perhaps not in full amount, but in some amount at least. The problem, however, is somewhat easier than in the case of interest. It is always possible to go to the company's books and find the amount of taxes the company is actually paying, also the rate, but it is not always possible to find the ratio of assessed to actual value.

It also becomes necessary to estimate just what percentage of the property under construction the assessor will find and put on the rolls. It is also necessary to consider whether the date of starting construction and the date of assessment are the same, or whether the assessment is made in mid-year of each year of the construction period. The final result will not be very different with two methods. The following problem is presented only to illustrate the solution under certain assumed conditions.

PROBLEM NO. 4:

Assume a property costing $12,000,000, of this amount the

(*Continued on page 597*)

The Design of Aspirators for Sterilizing Water

By A. E. WALDEN,[1] BALTIMORE, MD.

THE value of ozone as a sterilizing agent in the purification of water is well known. The means for uniting water and ozone or air, however, are not so clearly established, and in an effort to perfect the design of an aspirator which would efficiently accomplish this the writer conducted an extensive series of experiments which form the basis of this paper.

From the operating point of view, it was first of all essential that the heads of water pumped against be kept as low as possible. Data were unobtainable, however, concerning the relation of the volume of water to the volume of air that it was possible to combine or mix at low heads, or the possible variation of the two, which is of greater importance.

To obtain this information numerous different forms of aspirators, ejectors, siphons, jets, and nozzles were accordingly tested. Some of these, of the barometric-condenser type used for both steam and water, failed to give satisfactory results. Some that would work successfully with steam would not work with water; moreover, they would not handle large volumes of air. Others that would work well with large volumes of water could not be manipulated to vary the quantity of water and would not handle large volumes of air, or permit of varying the quantity of air to the quantity of water, and vice versa. Also some that were very satisfactory for use with condensers would not handle large quantities or volumes of air with water without a blowback of air, due to the fact that the column of water and air lacked weight or velocity to compress the air and keep the combination in a forward motion, a pressure equivalent to higher pressure than that in the mixing well or contact cell being required.

Experiments likewise showed that under low heads some aspirators would draw in a continuous draft of air but could not be varied; others, when the draft was heavy, would lower the specific gravity of the mixture to such a value that a blowback occurred and action ceased altogether; and that while it was possible to draw in air and water in a proportion of 1 to 3, by volume, the head should not be reduced much below 12 ft. for satisfactory operation. All of the above conclusions were reached by testing many different types and designs of aspirators and the first results that were at all satisfactory were obtained with a Knowles spirojector. This is shown in Fig. 1.

The Knowles spirojector, however, while giving fairly satisfactory results, did not function at low heads any better than other types; moreover, it is difficult to construct in either tile or enameled iron, inasmuch as the heat necessary to set the enamel will warp and distort the tube. If a tile-grinding process could be employed at a reasonable cost, it might be possible to eliminate some of the objections to this form of aspirator, such as the lack of flexibility in the variation of quantity of water, etc. In all cases, however, it was impossible materially to vary the quantity of air and ozone to water, and a pumping head of 34 ft. plus a pressure of 3 lb. per sq. in. was of course out of the question.

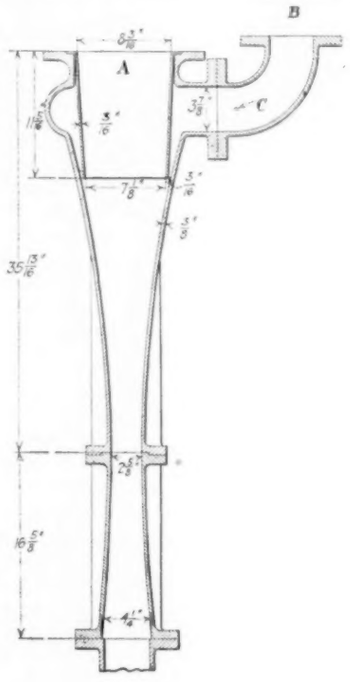

Fig 1 Fig. 3

FIG. 1 SECTIONAL VIEW OF THE KNOWLES SPIROJECTOR
When used as an aspirator, air enters at *A* and water at *B*. When measuring air velocity, opening *A* is reduced and an anemometer placed in the reduced opening. Pressure gage is located at *C*.

FIG. 3 SECTIONAL VIEW OF ASPIRATOR USED IN TESTS

In this connection it should be pointed out that air velocity tends to reduce the temperature and that if the humidity is

[1] Supt. and Chief Engineer, The Baltimore County Water and Electric Co., Mem. Am. Soc. M. E.

TABLE 1 SUMMARY OF RESULTS OBTAINED IN TESTING VARIOUS TYPES OF ASPIRATORS

No.	Type of Aspirator[1]	Discharge, cu. ft. water per min.	Air velocity, ft. per min.	Cu. ft. of air per min.	Pressure head, ft.-in.	Negative head, ft.-in.	Bacteria, per cent removal
1	3-in. Orifice	41	1100	45.0	5—9	8—0	97.58
2	3-in. Orifice	41	1090	44.7	6—0	8—0	85
3	2.5-in. Orifice	41	930	38.0	5—10½	8—0	95.6
4	3.5-in. Orifice	41	900	36.9	5—1	8—0	88.1
5	Tile Aspirator	41	1000	41.0	6—2	7—0	92.0
6	Nozzle 2-A, Throat No. 2, 2⅛ in. apart	24.5	590	24.1	5—8¾	7—0	98.8
7	Nozzle 2-A, Throat No. 3, 2⅛ in. apart	25	420	17.2	6—2	7—0	98.8
8	Nozzle 2-A, Throat No. 4, ¼ in. clearance around jet at throat	24	870	35.6	6—1	7—0	99.2
9	Nozzle No. 2-A, Throat No. 3	23	630	25.8	6—3	7—0	98.6
10	Nozzle No. 2-A, Throat No. 5	25	335	17.7	6—4	7—0	95.9
11	Nozzle No. 21, Throat No. 25	42	330	13.5	5—4	7—0	97.3
12	Nozzle No. 21, Throat No. 22	42	430	17.6	5—4	7—0	99.1
13	Nozzle No. 21, Throat No. 23	42	690	28.2	5—2	7—0	99.3
14	Nozzle No. 21, Throat No. 24	42	800	32.8	5—3	7—0	97.2
15	NozzleNo. 21, Throat No. 6	42	460	18.8	5—4	7—0	98.3
16	Nozzle with holes of 5 sets, Throat No. 25	22	725	29.7	6—1	7—1	99

[1] Tests Nos. 1-4 were made with a steel-plate orifice inserted at *D* in Fig. 3.
Test No. 5 was made with a tile nozzle inserted at *D* in Fig. 3.
Tests Nos. 6-16 were made with nozzles and throats of the shapes shown in Fig. 2.

high and the air impinges on a cold metal surface, such as a cooled tube, the dewpoint is quickly reached and moisture is immediately precipitated on the cool surface. If allowed to

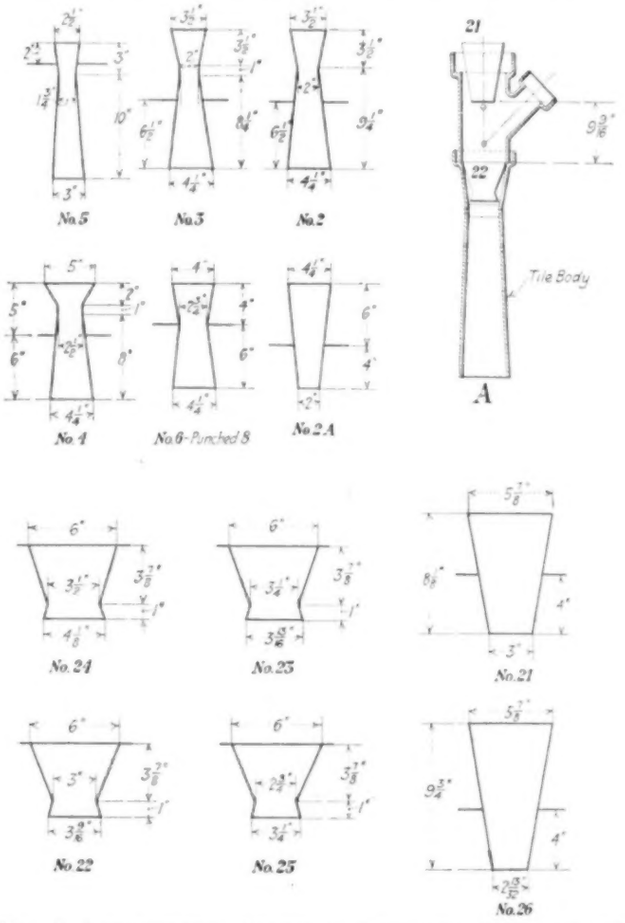

FIG. 2 EXPERIMENTAL ASPIRATOR WITH TILE BODY AND THE VARIOUS NOZZLES AND THROATS USED

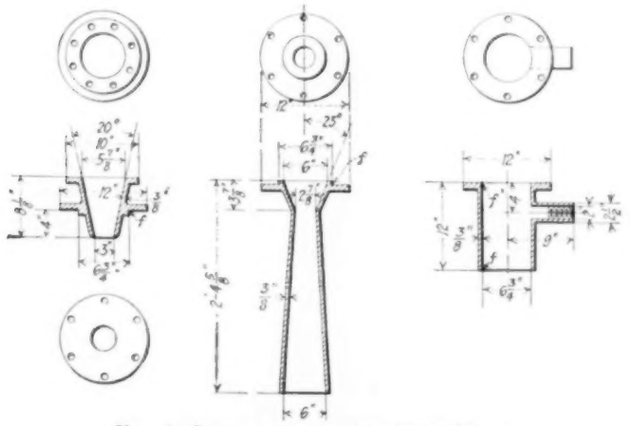

FIG. 4 DETAILS OF AN ASPIRATOR HEAD

continue it eventually causes rupture of the dielectric in the ozone generator. Humidity also reduces the quantity of ozone it is possible to produce. The reason therefor is not known at this time, unless it may be that moisture carries the static charge in such a way as not to affect the air itself. The above action, which has never before been mentioned by any experimenters, was accidentally discovered during the series of experiments conducted by the author.

As a result of these preliminary tests a new set of experiments were conducted using various tile nozzles and different throats inserted in a tile body as shown at *A* in Fig. 2. These nozzles and throats are also shown in Fig. 2. The results of the experiments conducted on these aspirators are given in Table 1, and the varied tests indicated therein show the successive steps which were taken in the selection of the type ultimately chosen.

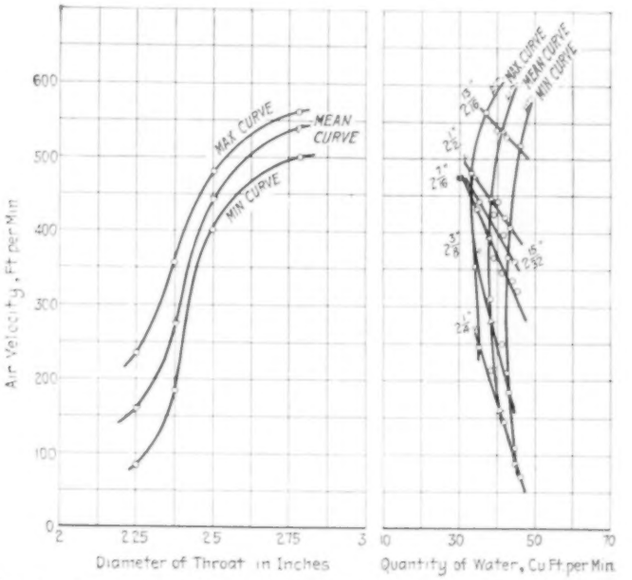

FIG. 5 CURVES SHOWING RELATION OF AIR VELOCITY TO DIAMETER OF THROAT AND TO QUANTITY OF WATER WITH VARYING SIZES OF THROATS (FOR 20-DEG. 3-IN. NOZZLE)

THE EFFECT OF VARYING HEAD

A series of tests were also made to determine the effect of varying both the positive and negative head, positive head being the elevation above the throat and negative head the distance from the throat to the tailwater. The results of these tests are given in Table 2 and summarized below.

The loss of 4 in. down the pipe, or tail pipe, was estimated to be equal to 0.08436 ft. per foot of pipe.

A test was made for the 2-in. nozzle for diameter of stream at contracted portion, which was found to be 1 13-16 in. at one-half the distance of 3 in. from end of nozzle; and discharging 33 cu. ft. under 5.75 ft. positive head and 7 ft. negative head sustained a column of water 81.5 in. high. Roughness or irregularity of the apparatus used, however, will vary these figures materially.

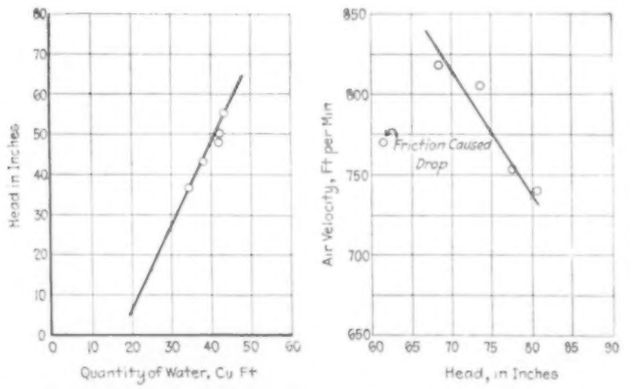

FIG. 6 CURVES SHOWING RELATION OF HEAD TO QUANTITY OF WATER AND AIR VELOCITY, FOR 20-DEG. 3-IN. NOZZLE

These tests indicate that the length of the jet discharged from the nozzle striking either at the throat or at some point in the

diverging tube below the throat gave the best results. As the tests were made the jets were examined by throwing light through the opening C, Fig. 3, so that the jet could be seen, and also through a side opening, which was straight, in a cast-iron special that was employed in place of tile B.

In every case the roughest discharge from the nozzle, if it impinged at or below the throat, drew in the greatest quantity of air. This led to the suggestion that a glass aspirator be constructed, but glass manufacturers would not undertake to make it except at an excessive price.

The appearance of the jet also suggested that possibly a nozzle giving a star-shaped or serrated surface discharge would aspirate a greater quantity of air to a given volume of water.

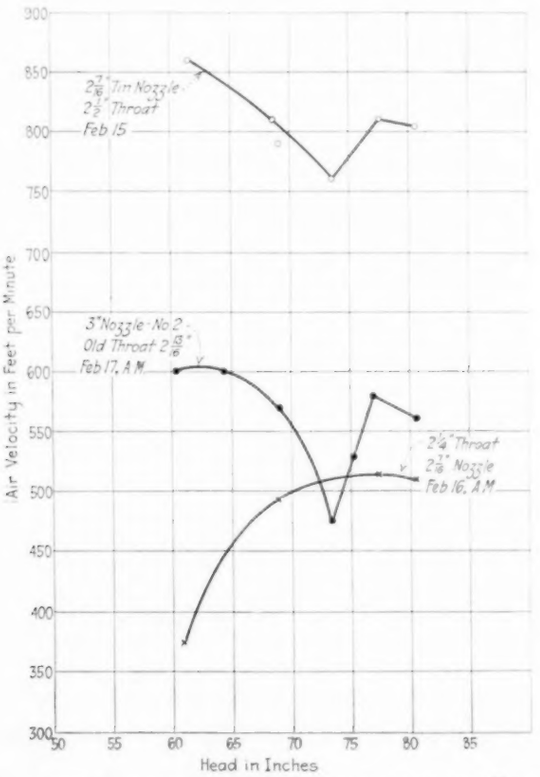

FIG. 7 CURVE SHOWING IRREGULAR CHARACTERISTICS FOUND IN A FEW OF THE LARGE NUMBER OF ASPIRATORS TESTED

These experiments led to the construction of three aspirators, one of which was later adopted and is shown in Fig. 4.

TABLE 2 RESULTS OF TESTS MADE TO DETERMINE EFFECT OF VARYING HEAD

No.	Type of Aspirator.	Discharge Cu. ft. Water per Min.	Air Velocity, Ft. Per Min.	Cu. Ft. Air Per Min.	Pressure Head, Ft. In.	Negative Head, Ft. In.
1	Tile Nozzle, Throat No. 22 ..	42	1015	41.6	7—0	7—0
2	" " Throat No. 25 ..	42	890	36.5	7—0	7—0
3	3-in Nozzle, 2⅞-in. Throat...	47	420	17.4	6—0	8—0
4	" " ...	46	380	15.6	6—0	8—0
5	" " ...	47	275	11.5	6—0	7—6
6	" " ..	47	200	8.2	6—0	6—0

All of these tests indicated the importance of providing not less than 20 per cent excess air velocity in testing over that in operation in sterilizing, to allow for friction in tail pipe and mixers or devices below the throat, including the change in the specific gravity of the mixture of air and water. This was necessary to keep the mixture in motion.

It was the intent to carry out further experiments to determine what would appear to be the slip of the bubbles of air in the tail pipe and the fact that they do not seem to fall at the same velocity as the column of water, or for some reason do not receive and hold the kinetic energy imparted to them. The bubbles decrease in size with increase of head and increase with a decrease of head, which is as it should be. The bubbles appear to rise at a rate of about 0.75 ft. per sec.

The specific gravity of the mixture of air and water, or ozone, when a certain entrainment is reached, is so low that the energy in a downward direction is lost and a blowback occurs in the air inlet, as before mentioned, which is similar to the air lift, and makes the mixture look like soap bubbles in the down pipe.

THE TYPE OF ASPIRATORS ADOPTED

The final aspirators were of cast iron, enameled with the best possible white porcelain enamel; but even this is subject to deterioration, due to high ozone concentration, which shows after about five years of operation. There seems to be no question as to the suitability of tile for aspirators when ground to suitable measurements.

The details of an aspirator head are shown in Fig. 4. The curves of Fig. 5 and 6 give its characteristics. Some experiments, however, would seem to indicate that the air intake and the time element of mixing might be changed profitably, considering the cost of handling the water, and that contact in a horizontal pipe beyond the tail pipe for a distance of 20 ft. will turn out a perfectly satisfactory effluent. The curves in Fig. 7 are inserted to show the irregular characteristics found in a few of the great number of aspirators tested before the final type was chosen.

John Ericsson Memorial Tablets

The members of The American Society of Mechanical Engineers doubtless remember the account published in the January 1920 issue of MECHANICAL ENGINEERING of the memorial meeting held during the Annual Meeting of this Society, on the evening of December 3, 1919, in commemoration of the eightieth anniversary of the arrival in the United States of Captain John Ericsson, his fifty years' association with Cornelius H. DeLamater in engineering work, and finally the thirtieth anniversary of the deaths of these two men in 1889 within one month of each other.

It had been decided previous to the memorial meeting that money left over from subscriptions to it should be set aside as a nucleus for a fund to be devoted to the erection of commemorative tablets to mark the sites of certain buildings which were closely identified with the work of Mr. DeLamater and Captain Ericsson. These buildings comprised: (1), the Phoenix Foundry at Laight and West Streets, New York City, where the first screw-propelled vessel in this country was constructed and where many other original developments were made; (2), Captain Ericsson's residence, 26 Beach Street, where he designed the *Monitor* and made all his inventions during his later years; (3), the DeLamater Iron Works, foot of West 13th Street, where the engines of the *Monitor*, *Puritan* and *Dictator* were constructed, as well as the first submarine boat, the first torpedo boat, the first torpedo boat destroyer, the first self-propelled torpedoes, the first dynamite gun, the first air compressors, ice machines and many other industrial appliances now in general use throughout the world; (4), the Continental Iron Works at Greenpoint, L. I., where the hulls of the *Monitor*, the *Puritan* and other warships were built.

A number of organizations have already subscribed to the tablet fund, either as a body or through individual members. The tablets will be unveiled on March 9, 1922, the sixtieth anniversary of the battle between the *Monitor* and the *Merrimac*, on which date also the John Ericsson Memorial Monument will be dedicated in Washington.

The individual members of the Metropolitan Section have been asked to subscribe to this fund, but it is believed that there are many members, as well as industrial firms, organizations and other individuals, located elsewhere who, from sentimental or patriotic motives, would also like to subscribe. Those interested should communicate with the DeLamater-Ericsson Tablet Committee, H. F. J. Porter, Chairman, Room 1100 Engineering Societies Building, 29 West 39th Street, New York, N. Y.

The Effect of Depth of Copper Plating on Carburization

By F. P. ZIMMERLI,[1] ANN ARBOR, MICH.

ALTHOUGH case hardening has been investigated considerably during the last few years, methods for preventing the cementation of steel in certain areas have received but little attention. Commercial plants which the writer has recently had occasion to visit have called his attention to the importance of the use of non-carburizing materials and the lack of knowledge concerning them. Most of these plants were using copper plating on all parts of the steel not to be cemented and in answer to inquiries regarding the amount used, the general reply was that they put on "enough."

While there are several non-carburizing materials in use, such as fireclay, or waterglass and calcium hydroxide mixed to form a paint, nevertheless copper plating has given the most satisfaction and it is estimated that it is employed by at least 75 per cent of the plants.

The object of the work described in the following paragraphs was to determine the least amount of copper which must be plated on a piece of steel in order that within a specified time no carbon shall have penetrated through the coating and gone into the steel.

The steel chosen for the experimental work was $\frac{3}{4}$-in. bar stock having the following percentage composition: C, 0.112; P, 0.012; S, 0.0365; Si, 0.128; Mn, 0.458. This was cut longitudinally into half-round pieces approximately 0.75 in. by 1.25 in. on the flat side. These pieces were then numbered and the flat sides, approximately 0.94 sq. in. in area, ground smooth and true on an emery wheel. These uniformly smooth surfaces were cleaned and the backs greased preparatory to plating. Pieces Nos. 1 to 10 inclusive were placed in the plating bath at one time and formed the first set, 11 to 20 the next set, etc., the time on each set being different to control the depth of copper plate.

The cyanide bath was made up as follows, the given quantities being for one liter of solution:

Na_2SO_3	20 grams
$Na_2CO_3 10H_2O$	20 grams
$NaHSO_3$	20 grams
$Cu(C_2H_3O_2)_2 H_2O$	20 grams
KCN (100 per cent)	20 grams

The specific gravity of such a solution is 1.0507 or 7 deg. B. The current density advised for plating is 0.003 ampere per sq. cm. and the copper deposited at 20 deg. cent. 2.3716 grams per ampere-hour. Because of gas evolution and deposition of copper on the backs of the pieces which no grease would seem entirely to keep off it could not be figured beforehand just how much copper would plate on, nor could the current be kept constant at 0.003 ampere per sq. cm. for each set. An effort was made, however, to keep to this value. It was necessary to guess at the percentage of the total surface exposed by the ten specimens in the bath because of gradual copper deposition on the back. The total area of any one piece was 2.867 sq. in. and of this it was desired to plate 0.955 sq. in.; and of a set, ten times that value.

In practice it was believed that 0.005 in. was not an unusual depth of plate. M. T. Lothrop in his paper on Case Carbonizing[2] reports that 0.0005 in. of copper is the least amount sufficient to prevent carbonization due to non-uniform coating giving unplated areas, but he does not state the current density used. This value he obtained by measurement with micrometers. The plating on the specimens used in this work was from 0.00000896 in. to 0.001815 in. thick, which values are both less and greater than that of Mr. Lothrop.

It was impossible either to figure in advance the amount of copper by knowing the current used as before mentioned, or to obtain the true value of copper deposited by weighing before and after plating, the iron displacing the copper in solution even when no current was used and the moisture condensed on the surfaces was appreciable. The tests were therefore continued as follows: The fifty pieces, sets 1, 2, 3, 4, and 5, depending on length of time in copper-plating bath, were divided so that set A consisted of ten samples, two from each of groups 1, 2, 3, 4, and 5. Sets B, C, D, and E were formed likewise. Two were taken from each of groups 1, 2, 3, 4, and 5 because when ten samples were immersed in the plating bath, five were on each side of the copper electrode. One piece from each side of the electrode for each time interval in the bath constituted a set. All copper but that on the flat surface was taken off. Several $2\frac{1}{2}$-in. iron pipes 8 in. long with caps were obtained and a small hole drilled in each, thus keeping the pressure atmospheric. Sets A, B, C, D, and E were packed in them with a carburizing mixture which analyzed as follows:

Charcoal	48.70 per cent
$BaCO_3$	10.56 per cent
Na_2CO_3	4.65 per cent
SiO_2	2.70 per cent
Al_2O_3	33.25 per cent

The specimens were packed face down in alternate layers with the carburizing material, the container being placed upright, and about an inch of the material was placed over the last specimens placed in a container.

Sets A, B, C, D, and E were carbonized at 1697 ± 3 deg. fahr. in a large gas furnace for 1, 2, 4, 8 and 12 hours, respectively. One-half hour was allowed for the container to reach furnace

TABLE 1 DATA OF TESTS TO SHOW EFFECT OF DEPTH OF COPPER PLATING ON CARBURIZATION OF LOW-CARBON STEEL SPECIMENS

	Piece Number	Time in furnace, at 1700 deg fahr., hours	Depth (δ) of copper deposit in $\frac{1}{}$ hundred thousandths of an inch.	Depth of case on steel, inches		Case under copper
				Eutectoid	Hypoeutectoid	
Set B	5	2	1.885	0.016	0.0186[1]	None
	10	2	1.850	0.0106	0.0186[1]	None
	15	2	22.79	0.0160	0.0160[1]	None
	16	2	20.80	0.0160	0.0106[1]	None
	23	2	89.25	0.0106	0.0187[1]	None
	20	2	55.25	0.0186	0.0186	None
	33	2	50.20	0.0106	0.0187	None
	38	2	55.60	0.0106	0.0187[1]	None
	45	2	145.50	0.0160	0.0214	None
	49	2	133.50	0.0160	0.0187	None
Set D	1	8	1.29	0.0453	0.0318	[2]
	8	8	1.78	0.0318	0.0318	None[4]
	12	8	17.8	0.0372	0.0266	None
	18	8	12.45	0.0453	0.0318	None
	24	8	76.95	0.0453	0.0318	None
	28	8	70.00	0.0453	0.0318	None
	31	8	53.25	0.0453	0.0342	None
	37	8	56.25	0.0480	0.0342	None
	41	8	144.50	0.0480	0.0342	None
	48	8	158.00	0.0480	0.0342	None
Set E	2	12	0.896	0.0372	0.0532	[5]
	9	12	3.02	0.0532	0.0372	Cu broken[6]
	11	12	20.30	0.0532	0.0532	None
	17	12	11.98	0.0318	0.0266	[7]
	25	12	73.50	0.0590	0.0372	[8]
	30	12	66.00	0.0343	0.0398	None
	34	12	88.25	0.0372	0.0508	None
	39	12	46.70	0.0372	0.0560	[9]
	42	12	163.10	0.0318	0.0508	None
	47	12	124.10	0.0560	0.0398	None

[1] Uneven. [2] Very uneven. [3] Raise of 0.11 to 0.2 per cent C at extreme edge near copper. Copper off in places. [4] Copper off in places. [5] Raise of 0.11 to 0.15 per cent C at extreme edge near copper. Copper mostly off. [6] Copper off in places. [7] Practically none. [8] 0.1 to 0.2 per cent. [9] Raise of 0.11 to 0.2 per cent.

[1] Department of Chemical Engineering, University of Michigan.
[2] Trans. Am. Soc. M. E., vol. 34 (1912), p. 939.

temperature and it took the furnace 10 hr. to cool down to 291 deg. fahr. after being shut off, at which temperature the sets were removed from the furnace.

Upon opening the containers all specimens were examined for oxidation of iron or copper. The exposed iron was first coated with paraffin and nitric acid then used to remove all the copper from the surface. The percentage of copper was determined electrolytically. At the time of this analysis it was realized that the iron might have dissolved some of the copper and some might have been carried off mechanically, but it is felt that in this manner there was less error introduced than in any other.

The specimens were all sawed in half, polished and etched. They were then examined microscopically for case depth under the copper plating and on the back where there was no copper deposition. The case was always examined for free cementite, which was not found until Set E was reached, where it occurred in some of the specimens; however, it was so very shallow that it was figured in the eutectoid. The hypoeutectoid was measured to a point wherein it was estimated that there was not over 0.15 to 2 per cent carbon, since from such a low percentage it decreased rapidly to the 0.11 per cent of the original steel.

(*Continued on page 602.*)

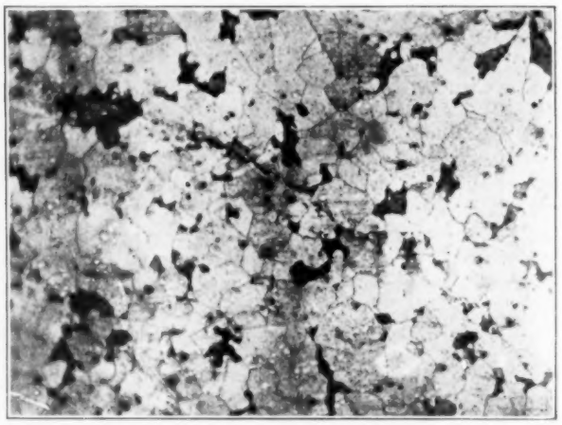

Fig. 1 Photomicrograph of Untreated Specimen Etched with 5 per cent Nitric Acid (× 100)

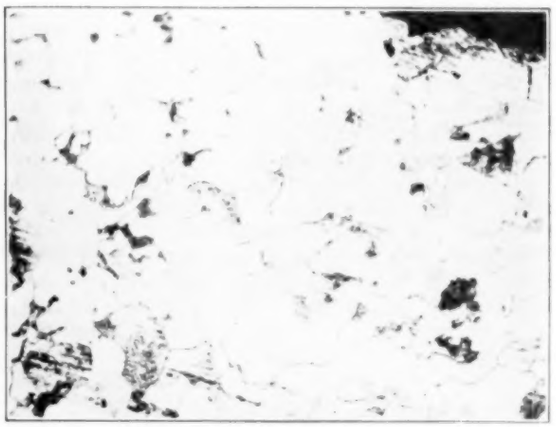

Fig. 2 Under Copper Plating, Showing Edge of Piece. Etched with 5 per cent Nitric Acid (× 100)

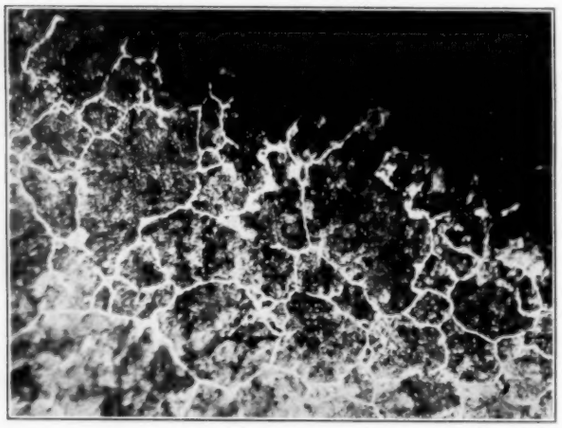

Fig. 3 Unplated Edge, Showing Case. Etched with 5 per cent Nitric Acid (× 100)

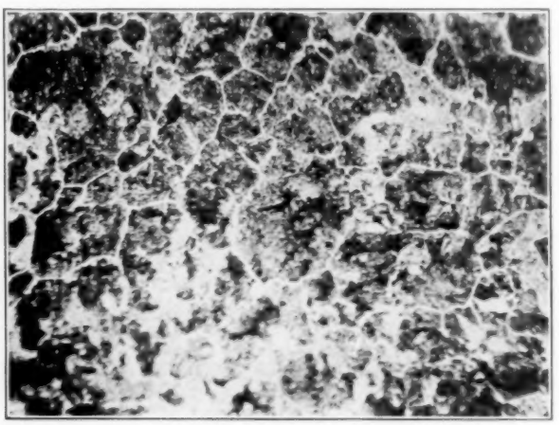

Fig. 4 Same as Fig. 3, Except Farther from Edge of Specimen (× 100)

Fig 5 Unplated Edge, Showing Case. Same as Fig. 4 (× 350)

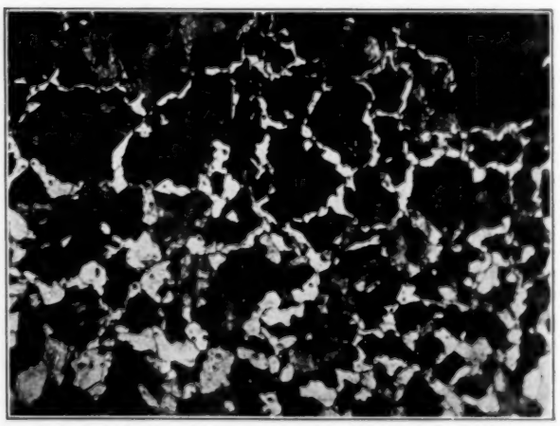

Fig. 6 Case Still Farther from Edge than in Fig. 4

Notes on Electric Welding

AT a meeting of the Washington Section of the A.S.M.E. on May 17 of this year, two papers on electric-arc welding were presented, one by Mr. H. S. Rawdon of the Bureau of Standards and the other by Mr. O. H. Eschholz of the Westinghouse Electric & Manufacturing Co. Data are given by these authors on the strength of the joint and the properties of arc-fused metal.

THE ELECTRIC-ARC WELDING OF STEEL: THE PROPERTIES OF THE ARC-FUSED METAL

By HENRY S. RAWDON,[1] WASHINGTON, D. C.

A FUSION weld is fundamentally different from all other types in that the metal of the weld is essentially a casting. The arc-fusion weld has characteristics quite different from other fusion welds. The results of a study of the properties of the arc-fused metal which has been carried out by the Bureau of Standards may be of sufficient interest to warrant presentation before this body. For details the Technologic Paper of the Bureau upon this subject should be consulted.

The application of arc welding in the shipbuilding industry is one of the most important and extensive applications which has ever been proposed for this method. During the year 1918, at the request of and with the coöperation of the Welding Research Sub-Committee of the Emergency Fleet Corporation, an extensive program was outlined by the Bureau of Standards for the study of this type of welding. The principal object of the research was the determination in an empirical way by actual welding tests carried out by skilled operators the relative values and merits of the different types of electrodes or welding pencils which are available commercially for the purpose. Due to changed conditions, however, at the close of the year 1918, the original program was modified and shortened very considerably.

In drawing up the modified program it was decided to make the study of the characteristic properties of the fused-in metal, the primary object of the investigation, the study of the merits of the different types of electrodes being a secondary one. Since

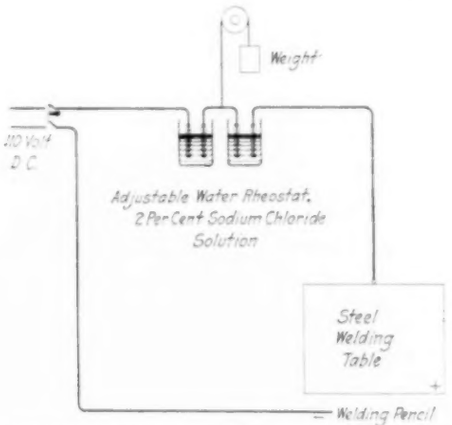

FIG. 1 DIAGRAM OF APPARATUS USED IN THE PREPARATION OF THE SPECIMENS OF ARC-FUSED METAL

the metal of any weld produced by the electric-arc fusion method is essentially a casting, as there is no refinement possible as in some of the other methods, it is apparent that the efficiency of the weld is dependent upon the properties of this arc-fused metal. Hence a knowledge of its properties is of fundamental importance in the study of electric-arc welds.

Though the results available at present are not as conclusive throughout the entire series of examinations made as might be desired, it is believed that they contribute very materially to our knowledge of the properties of the fused-in metal which is ultimately the deciding factor as to the serviceability of the electric-arc weld. The investigation included a study of the composition changes which accompany the fusion of the metal, the determination of the mechanical properties of the arc-fused metal together with the examination of the structure of the metal after fusion, in the endeavor to explain the observed mechanical and chemical characteristics.

The specimens required for the study of the mechanical properties of the arc-fused iron were prepared for the most part at the Bureau of Standards, direct current being used in all the operations. The apparatus used is shown diagrammatically in Fig. 1. By the use of automatic recorders the voltage and current were measured and records were taken at intervals during the preparation of a specimen.

Since the investigation was concerned primarily with the properties of the arc-fused metal, regular welds were not made. Instead the metal was deposited in the form of blocks (Fig. 2), each one being large enough to permit a tension specimen (0.505

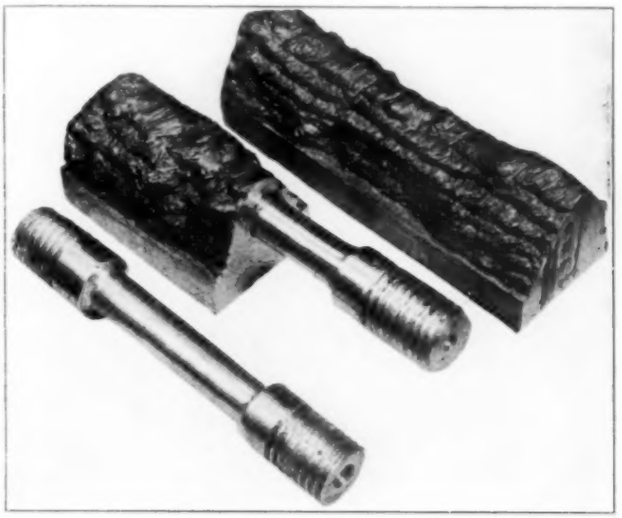

FIG. 2 BLOCKS OF ARC-FUSED METAL WITH TENSION SPECIMEN CUT THEREFROM

in. in diameter, 2 in. gage length) to be machined out of it. Although the opinion is held by some welders that the properties of the metal of an arc weld are affected materially by the adjacent metal by reason of the interpenetration of the two during fusion, it was decided that the change of properties of the added metal induced by fusion alone, was of fundamental importance and should form the basis of any study of arc welding. The method adopted also permitted the use of larger specimens with much less machining than would have been possible had the metal been deposited in the usual form of a weld. The block of arc-fused metal was built up on the end of a section of ½-in. plate of mild steel (ship plate). When a block of sufficient size had been built up, it, together with the portion of the steel plate immediately beneath, was sawed off from the remainder of the steel plate. The tension specimen was turned entirely out of the arc-fused metal. No difficulty whatever was experienced in machining the specimens.

In general, in forming the blocks, the fused metal was deposited as a series of "beads," so arranged that they were parallel to the axis of the tension specimen which was cut later from the block. For purposes of comparison in a few specimens, the metal was deposited in beads at right angles to the length of the block. In all the specimens, after the deposition of each layer, the surface was very carefully and vigorously brushed with a stiff wire brush, to remove the layer of oxide and slag which formed during the fusion. There was found to be but little need to use the chisel for removing this layer.

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Tension specimens only were prepared from the arc-fused metal. It is quite generally recognized that the tension test falls very short in completely defining the mechanical properties of any metal; it is believed, however, that the behavior of this material when stressed in tension is so characteristic that its general behavior under other conditions of stress, particularly when subjected to the so-called dynamic tests, i. e., vibration and shock, can be safely predicted from the results obtained. In order to supplement the specimens made at the Bureau a series was also prepared by one of the large manufacturers of equipment for electric welding to be included in the investigation.

FIG. 3 MICROSTRUCTURE OF "PURE-IRON" TYPE OF ELECTRODE USED (× 100)

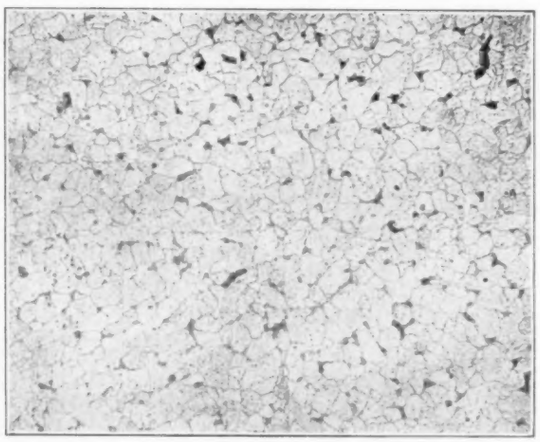

FIG. 4 MICROSTRUCTURE OF LOW-CARBON STEEL ELECTRODE USED (× 100)

Two types of electrodes were used as material to be fused. These differed considerably in composition and were chosen as representative of a "pure" iron and a low-carbon steel (see microstructures in Figs. 3 and 4), the approximate carbon content of the two being respectively 0.02 and 0.15 per cent. Each type was obtained in sizes ranging from ⅛ in. in diameter to ¼ in., so that a considerable range of current densities was possible. The electrodes were used both in the bare condition and after being slightly coated with a paste of an oxidizing and refractory nature, the purpose being to prevent excessive oxidation of the metal of the electrode during fusion and to form also a thin protective coating of slag upon the fused metal.

CHANGES IN COMPOSITION OF ELECTRODES AS A RESULT OF FUSION

In general, the effect of the fusion in the arc is to render the metal of two electrodes quite similar in composition. The data summarized in Table 1 are typical of the changes.

TABLE 1 PERCENTAGE COMPOSITIONS OF ELECTRODES BEFORE AND AFTER FUSION

Type	A		A		B	
Size, in.	⅛		¼		⅛	
	Before	After	Before	After	Before	After
Carbon	0.038	0.031	0.022	0.010	0.15	0.024
Silicon	0.33	0.007	0.16	0.012	0.06	0.008
Manganese	0.042	tr.	0.038	tr.	0.47	tr.
Phosphorus	0.002	0.005	0.002	0.002	0.018	0.002
Sulphur	0.057	0.036	0.040	0.033	0.021	0.035
Nitrogen[1]	0.0030	0.143	0.0040	0.126	0.0032	0.140

[1]Average of several determinations on different electrodes of same size and type.

The loss of carbon and of silicon is very marked in each case the nitrogen content of the metal. In general the increase was where these elements exist in considerable amounts. A similar tendency also exists for manganese.

The most noticeable change in composition is the increase in the nitrogen content of the metal. In general the increase was rather uniform for all specimens. In Fig. 5 the average nitrogen contents found for the different conditions of fusion are plotted against the corresponding current densities. Though no definite conclusion seems to be warranted, it may be said that, in general, the percentage of nitrogen taken up by the fused iron increases somewhat as the current density increases. With the

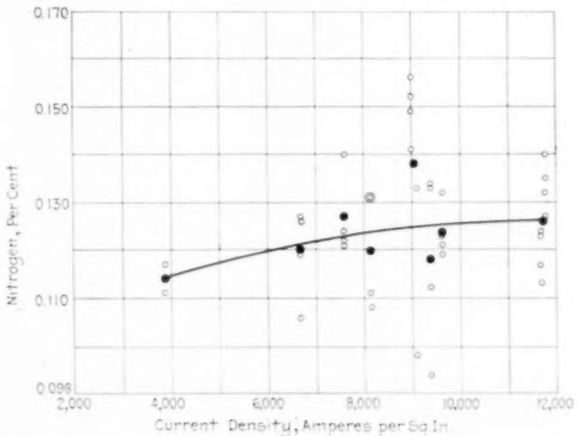

FIG. 5 RELATION OF THE NITROGEN CONTENT OF THE ARC-FUSED METAL TO THE CURRENT DENSITY

lowest current densities used the amount of nitrogen was found to decrease appreciably. Other investigators in this line have reported an increase in nitrogen content under similar conditions.

MECHANICAL PROPERTIES OF THE ARC-FUSED METAL

When it is considered that the metal which forms a fusion weld is essentially a casting, it is not surprising that there should be a very considerable difference between the mechanical properties of the metal in the form of electrodes or welding pencils and the same after fusion. The average tensile properties of the two types of electrodes are as given in Table 2.

TABLE 2 AVERAGE TENSILE PROPERTIES OF PURE-IRON (A) AND LOW-CARBON STEEL (B) ELECTRODES

Type of Electrode	Ultimate Strength, lb. per sq. in.	Proportional Limit, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent.
A	61,000	40,000	14	68
B	86,000	63,000	6	55
	67,000	37,000	15	61

The size of the electrode tested and the physical state of the metal, that is, the amount of cold working the metal received, cause rather wide variations in the properties. After fusion, however, the properties are very different, as shown in Table 3.

TABLE 3 TENSILE PROPERTIES AND HARDNESS OF ARC-FUSED METAL

Type of Electrode	Average Ultimate Strength, lb. per sq. in.	Average Yield Point, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area per cent	Brinell Hardness	Shore Hardness
A (bare)[1]	48,900	35,300	7.9	10.0	103	16.6
A (covered)[1]	46,600	34,600	8.5	9.0	103	16.6
B (bare)[1]	48,800	34,200	8.5	10.5	103	16.0
B (covered)[1]	47,400	32,200	9.9	13.8	103	16.0
C[2]	49,900	32,700	11.0	17.6	113	17.0

[1]"Bare" electrodes were those which were used in the conditions as received "covered" ones were coated as mentioned in the text.

[2]These specimens were prepared by a large welding firm and submitted to the Bureau to be included in the series.

The variations for the specimens of any particular type of electrode are rather wide, usually within the limits of ± 6 per cent. No definite conclusions could be drawn concerning the merits of the various electrodes. All the specimens have properties similar to those of steel castings of a rather inferior grade; the variations noted are of the order which might be expected for such cast steel of inferior quality. There does not appear to be any material advantage so far as the properties of the metal obtained were concerned in coating the electrodes. The specimens

FIG. 6 FRACTURED END OF A TENSION SPECIMEN AFTER TEST; NATURAL SIZE

Nearly all the specimens upon fracturing revealed a defect similar to the one shown above.

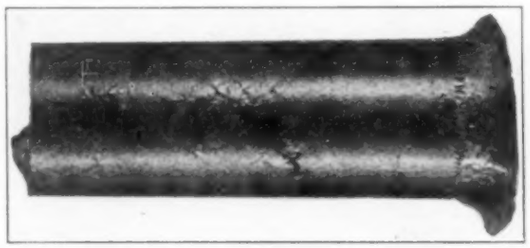

FIG. 7 SIDE VIEW (NATURAL SIZE) OF THE TENSION SPECIMEN SHOWN IN FIG. 6

which were prepared by different operators compare very favorably with each other. The most striking feature in the mechanical properties is the low ductility of the metal.

The characteristic appearance of the specimens after testing, illustrating their behavior when stressed in tension until rupture occurs, is shown in Figs. 6 and 7. The features shown are quite typical of the set of specimens. The fracture in all cases revealed interior flaws and defects. Although the results of the tension test appeared to indicate a fair elongation, examination of the specimens showed that the measured elongation does not truly represent a property of the material, but is due rather to the interior defects which indicate lack of perfect union of succeeding additions of metal during the process of fusion. The surface features of the specimens after stressing are very similar to those seen in the type of defective steel familiarly known as "flaky," which was a source of much discussion and delay of production during the progress of the war.

As previously noted, specimens were prepared for the purpose of showing the relation between the direction in which the stress is applied and the manner of deposition of the metal. The metal was deposited so that the beads of fused metal extended across the piece rather than lengthwise, hence the beads were at right angles to the direction in which the tensional stress was applied. The results of the tension tests are given in Table 4 and show that these two specimens (1 and 2) were decidedly inferior to those prepared in the other manner.

STRUCTURAL FEATURES

The general condition of the metal resulting from the arc fusion is shown in Figs. 8 and 9, which represent longitudinal

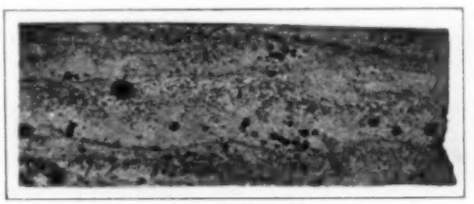

FIG. 8 LONGITUDINAL SECTION OF A TENSION SPECIMEN OF ARC-FUSED METAL

Natural size; polished and etched with copper-ammonium chloride solution to accentuate internal defects.

sections of tension specimens. The metal in all of these specimens was found to contain a considerable number of cavities and oxide inclusions, these are best seen after the polished surfaces are etched with a 10 per cent aqueous solution of copper-ammonium chloride. In many of the specimens the successive additions of metal are outlined by a series of very fine inclusions (probably

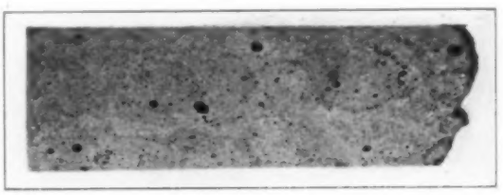

FIG. 9 LONGITUDINAL SECTION OF A TENSION SPECIMEN OF ARC-FUSED METAL

Natural size; polished and etched with copper-ammonium chloride solution to accentuate internal defects.

oxide) which are revealed by the etching. There appears to be no definite relation between the soundness of the metal and the conditions of deposition, i. e., for the range of current density used; nor does either type of electrode used show any decided superiority over the other with respect to porosity of the resulting fusion. The condition of the material prepared by experienced "practical" welders is quite similar to that prepared by the Bureau.

TABLE 4 TENSILE PROPERTIES OF THE SPECIMENS TESTED

Specimen	Ultimate Strength, lb. per sq. in.	Proportional Limit, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent
1	40,450	22,500	6.5	8.5
2	39,500	22,500	4.0	3.0

It is to be expected that the microstructure of the material after fusion will be very considerably changed, since the metal is then essentially the same as a casting. It has some features, however, which are not to be found in steel as ordinarily cast. The general type of microstructure was found to vary in the different specimens and to range from a condition which will be designated as "columnar" to that of a uniform fine equi-axed crystalline arrangement. This observation held true for both types of electrodes, whether bare or covered. In the examination of cross-sections of the blocks of arc-fused metal it was noticed that the

equi-axed type of structure is prevalent throughout the interior of the piece and the columnar is to be found generally nearer the surface, i. e., in the metal deposited last. It may be inferred from this that the metal of the layers which were deposited during the early part of the preparation of the specimen is refined considerably as to grain size by the successive heatings to which it is subjected as additional layers of molten metal are deposited. The general type of structure of the tension bars cut from the blocks of arc-fused metal will vary considerably according to the amount of refining which has taken place as well as the relative position of the tension specimen within the block. In addition it was noticed that the columnar and coarse equi-axed crystalline condition appears to predominate with fusion at high current densities.

In all of the specimens of arc-fused metal examined microscopically there were found numerous tiny globules of oxide as shown in Fig. 11. In general they appear to have no definite arrangement but occur indiscriminately throughout the crystals of iron.

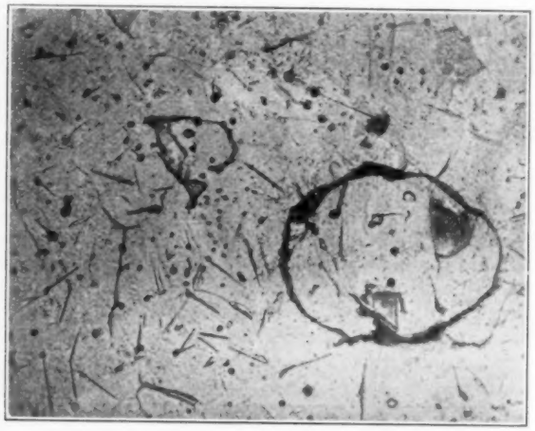

FIG. 10 MICROSCOPIC EVIDENCE OF UNSOUNDNESS

The globule at the right is surrounded by a film of oxide, and the fracture of specimens when tested in tension originates in such unsound areas.

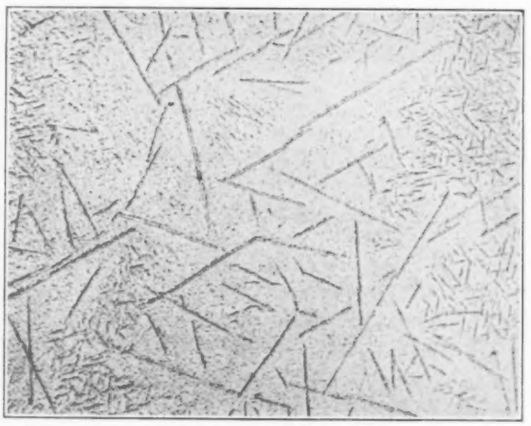

FIG. 12 NITROGENIZED IRON, SHOWING CHANGE IN STRUCTURE CAUSED BY HEATING IN AMMONIA

Electrolytic iron was nitrogenized by heating it for several hours (approx. 650 deg. cent.) in ammonia. The change in structure is due to the nitrogen which is taken up. Compare with Fig. 11. (×500)

A type of unsoundness frequently found is that shown in Fig. 10, which will be referred to as "metallic globule inclusions." In general these globules possess a microstructure similar to that of the surrounding metal but are enveloped by a film, presumably of oxide. It seems probable that they are small metallic particles which were formed as a sort of spray at the tip of the electrode and which were deposited on the solidified crust surrounding the pool of molten metal directly under the arc. These solidified particles apparently are not fused in with the metal which is subsequently deposited over them, i. e., during the formation of this same layer and before any brushing of the surface occurs.

The most characteristic structural feature of the metal after fusion is the presence of numerous needles or plates within the ferrite crystals. The general appearance of this feature is shown in Fig. 11. The number and distribution of these needles were found to vary greatly in different specimens; in general, however, they are most abundant in the columnar and in the coarse equi-axed crystals. Their distribution within the individual crystals indicates that they are arranged along the crystallographic planes.

The usual explanation of these plates is that they are due to the nitrogen which is taken up during the fusion. Other suggestions offered by different investigators at various times are to the effect that they are due to oxide and to carbide. While it is

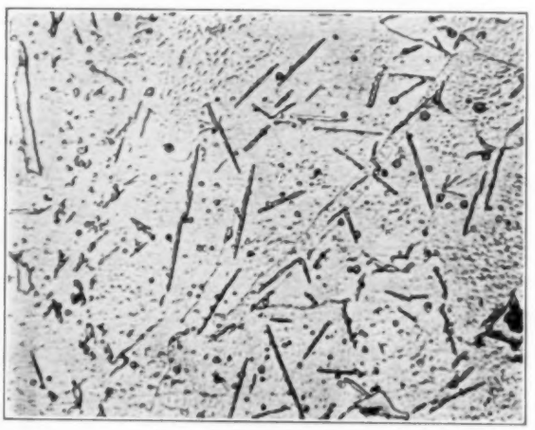

FIG. 11 CHARACTERISTIC FEATURE OF ARC-FUSED IRON

The "needles" or "plates" are due to the increase which occurs in the nitrogen-content during fusion. (×500)

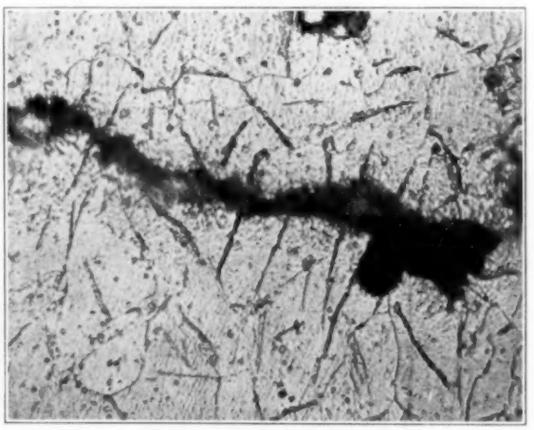

FIG. 13 RELATION OF PATH OF RUPTURE TO THE MICROSTRUCRURE OF ARC-FUSED IRON

The course of the crack or tear in the metal which was produced by stressing in tension does not appear to have been influenced appreciably by the "nitride plates." (×500)

not to be denied that the oxide content increases to a very pronounced exent—as is evident from the microscopic examination of any specimen of weld metal whatever, the characteristic appearance of such oxide inclusions, as well as their behavior when the specimen is heated for long periods (e.g., 6 hours at 1000 deg. cent. was used in some of the experiments) makes the suggestion that oxide forms the substance of such plates or needles seem very improbable. Likewise the suggestion of carbide may also be dismissed. The tendency during fusion is for the carbon to be "burnt out" of the metal and only a small amount remains. In practically all of the specimens enough carbide (as pearlite) may be found to account for the carbon content of the metal as revealed by the chemical analysis. The fact that the nitrogen

content increases during fusion and also that iron which has been nitrogenized under known conditions has a structure practically identical with that of the arc-fused metal, is very strong evidence in favor of the view that the nitrogen is responsible. See Fig. 12. When once combined with the iron the nitrogen is eliminated only with great difficulty. A heating of six hours in vacuo at 1000 deg. cent. (1830 deg. fahr.) reduced the nitrogen by about only 50 per cent of its initial value.

The pronounced effect of the nitrogen which is gained by the metal during fusion upon the thermal characteristics of the iron in the partial suppression and lowering of the transformation changes is shown in Fig. 14. The suggestion that such a pronounced change in the structure of the metal should have a similar pronounced effect upon the mechanical properties of the metal is a reasonable one. Numerous microscopic examinations were made with the aim of demonstrating to what extent the properties are affected, particularly whether these plates determine to any pronounced extent the course of the fracture of the specimen when broken in tension. It appears, however, as shown in Fig. 13, that the path of rupture is not affected appreciably by these so-called "nitride-plates." The effect of the grosser imperfections of the metal, i. e., oxide inclusions and films, "metallic globule" inclusions, and lack of adhesion between successive layers of the weld metal, is so much greater than any possible effect of the nitride plates in determining the mechanical properties of the specimen as a whole that the conclusion appears to be warranted that this feature of the structure is a matter of relatively minor importance in ordinary arc welds.

In arc-fusion welds in general the mass of weld metal is in intimate contact with the parts which are being welded, so that it is claimed by many that because of the diffusion and intermingling of the metal under repair with that of the electrodes the properties of the latter are considerably improved. The comparison shown in Table 5 somewhat supports this claim. The nearest comparison found available with the Bureau's specimens are some of those of the welds designated as the "Wirt-Jones" series reported by H. M. Hobart of the Research Committee of the American Welding Society. The welds were of the 45-deg. double-V type made in ½-in. ship plate; the specimens for test were of uniform cross-section, 1 in. by ½ in., the projecting metal at the joint having been planed off even with the surface of the plates, and the test bars were so taken that the weld extended transversely across the specimen near the center of its length. The electrodes used were similar to those designated as type B in the Bureau's investigation.

In any consideration of electric-arc welding it should be constantly borne in mind that the weld metal is simply metal which has been melted and has then solidified *in situ*. The weld is essentially a casting, though the conditions for its production are very different from those ordinarily employed in the making of steel castings. The metal loses many of the properties it possesses when in the wrought form, and hence it is not to be expected that a fusion weld made by any process whatever will have all the properties that metal of the same composition would have when in the forged or rolled condition. A knowledge of the characteristic properties of the arc-fused iron is then of fundamental importance in the study of the electric-arc weld.

The peculiar conditions under which the fusion took place also render the weld metal quite different from similar metal melted and cast in the usual manner. It is seemingly impossible to fuse the metal without serious imperfections. The mechanical properties of the arc-fused metal are therefore dependent to an astonishing degree upon the skill, care, and patience of the welding operator. The very low ductility shown by specimens when stressed in tension is the most striking feature observed in the mechanical properties of the material as revealed by the tension test. As explained above, the measured elongation of the tension specimen does not truly indicate a property of the metal. Due to the unsoundness already referred to in the discussion of the structure, the true properties of the metal are not revealed by the tension test to any extent. The test measures, largely for each particular specimen, the adhesion between the successively added

TABLE 5 COMPARISON OF BUREAU OF STANDARDS AND WIRT-JONES TESTS

Bureau of Standards Tests			Wirt-Jones Tests		
Electrode	Ultimate Strength, lb. per sq. in.	Elongation in 2 in., per cent	Electrode	Ultimate Strength, lb. per sq. in.	Elongation in 2 in., per cent
⅜ in.	48,700	8.0	⅛ in.	54,900	10.0
⅛ in.	48,600	10.0	⅛ in.	59,800	9.0

layers, which value varies considerably in different specimens due to the unsoundness caused by imperfect fusion, oxide and other

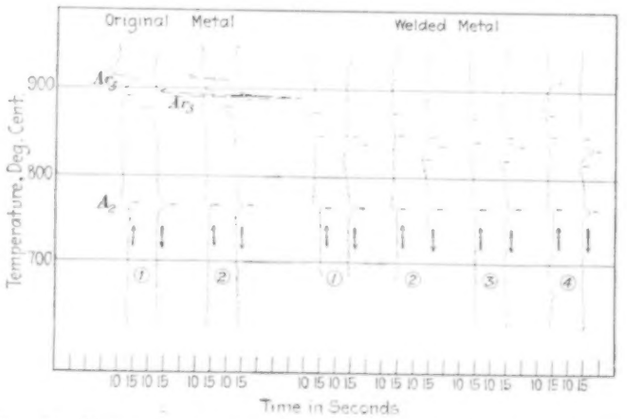

FIG. 14 EFFECT OF ARC FUSION UPON THE THERMAL CHARACTERISTICS OF LOW-CARBON STEEL

The metal originally contained 0.02 per cent carbon; after fusion the composition is very similar except that it has taken up nitrogen to the extent of 0.13 per cent.

inclusions, tiny enclosed cavities and similar undesirable features. The elongation measured for any particular specimen is due largely, if not entirely, to the increase of length resulting from the combined effect of the numerous tiny imperfections which exist throughout the sample.

That the metal is inherently ductile, however, is shown by the behavior upon bending as recorded in the microstructure of the bent specimen. The formation of slip bands within the ferrite grains to a very marked extent occurs under such conditions and is evidence of a high degree of ductility. It appears, however, that the grosser imperfections are sufficient to prevent any accurate measurement of the real mechanical properties of the metal from being made. The conclusion appears to be warranted, therefore, that the changes of composition which the fusion entails, together with the unusual features of microstructure which accompany the composition change, are of minor importance in determining the strength, durability, and other properties of the arc weld.

Since the specimens used in the work described were prepared in a manner quite different from the usual practice of arc welding, no definite recommendations applicable to the latter can be based upon the results. It appears, however, from the results obtained that the two types of electrodes used, i. e., "pure" iron and low-carbon steel, should give very similar results in practical welding. This is due to the changes which occur during the melting, so that the resulting fusions are essentially of the same composition. In fact, the most valuable conclusion which the results of the study warrant is that an arc weld is essentially a casting the properties of which are determined to a very large extent by the skill, ingenuity, and experience of the operator. If this essential characteristic of arc welds is borne in mind, the method will not be used in places where it is evident from the conditions of stresses existing in service that a casting should not be used, and it will also determine in innumerable cases that arc welding is the most efficient method to be considered.

METALLIC-ELECTRODE ARC-WELDING PROCESS

By O. H. ESCHHOLZ,[1] EAST PITTSBURGH, PA.

THE metallic-electrode arc-welding process is essentially a method for casting mild steel on a properly fused surface. Upon drawing an arc between a wire electrode and a metal surface, electrical energy is converted into thermal energy which serves to fuse the metal at both terminals. When a short arc length, ⅛ in. or less, is maintained, molten filler electrode metal is conveyed automatically to a fused surface.

The basic phenomena in fusion welding are those affecting metal transition. Upon drawing an arc with bare electrodes in downward welding, a pool of molten metal is formed at the positive or plate terminal and a liquid globule at the end of the negative terminal. This globule enlarges, with the continued application of energy, until the retaining forces, surface tension and cohesion, are exceeded by the globular weight, when the metal drops to the plate. Upon holding a short arc, globule growth is

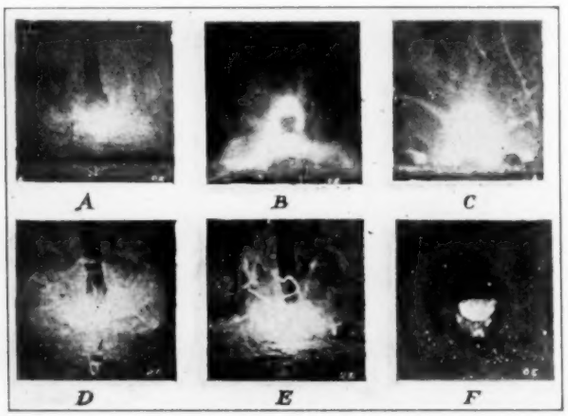

FIG. 1 METAL DEPOSITION

a, *b*, *c*, illustrate growth, release and deposition of liquid globule; *d* and *e* show electrode before and after deposition; *f* shows the appearance of electrode end immediately after interrupting arc.

limited by contact with the fused plate surface, and the forces of surface tension and adhesion at the contact area then assist the force of gravity in removing the molten globule.

It is evident that with a given electrode the rate of metal deposition may be increased, within limits, upon shortening the arc length. Electrodes differ in the speed and size of globule formation. The deposition rate has been observed to vary from two to sixty globules a second and the globule diameter from 1-32 in. to 5-32 in., depending upon the energy density, electrode analysis, preparation and arc length. The appearance of the negative or globular electrode terminal is indicative of its constituents and process of manufacture.

In Fig. 1 are shown high-speed photographs of the arc stream and terminals during metal transition. In this figure, *a*, *b* and *c* illustrate, respectively, the growth, release and deposition of metal under the exaggerated condition of maintaining a long arc with a large globule-forming electrode of high carbon content; *d* and *e* show respectively the appearance of the arc and a low-carbon steel electrode immediately before and after metal deposition; and *f* gives a view of the globular terminal immediately after interrupting the arc.

The sequence of circuit phenomena[2] accompanying metal deposition is shown graphically in Fig. 2. The initial rush of current at electrode contact serves to accelerate metal fusion. In the succeeding interval, globular growth occurs until contact is made with the plate, short-circuiting the arc. This causes a drop in arc voltage but an increase in current, the added energy obtained in the contact resistance tending to replace the energy developed at the arc terminal and thereby maintain the metal in a fused state.

[1] Research Engineer, Westinghouse Electric and Manufacturing Company.

[2] Metal Deposition in Metallic Electrode Arc Welding, by O. H. Eschholz, *Electrical World*, June 26, 1920, and July 17, 1920.

PHYSICAL PROPERTIES OF ARC-DEPOSITED METAL

Although this subject would appear to be of primary importance in the design and execution of welded structures, very few data are available concerning it. The refining[3] action of the atmospheric gases on the transferred metal is now, however, recognized.

The following analyses are typical of metal deposited from *bare* wire electrodes:

	C	Mn	P	S	Si
Electrode	0.16	0.56	0.032	0.024	0.016
Deposited Metal	0.05	0.18	0.031	0.036	0.011
Electrode	0.049	0.021	0.025	0.007	0.08
Deposited Metal	0.05	0.018	0.020	0.015	0.011

The variation in analysis of the conveyed metal is determined by the degree of exposure to oxidation. Upon holding a short arc length and employing special impregnated, covered or coated electrodes, which develop an arc-enveloping screen of inert gases, the analysis of deposited metal will approximate that of the filler electrode.

To determine the physical properties of *arc-deposited metal* test coupons were taken, respectively, from 7-lb. and 14-lb. deposits. In forming these the welder employed a short arc length, an arc current of 175 amperes and a 5-32 in. diameter low-carbon steel bare electrode. The metal was deposited in layers, each succeeding tier being at right angles. The surface of each tier in the 7-lb. deposit was sand-blasted, while in the 14-lb. deposit it was cleaned with a wire brush, which is the practice usually followed.

TABLE 1 RESULTS OF TENSILE TESTS ON MATERIAL IN 7-LB. DEPOSIT OF ARC METAL

Test No.	U. T. S.	Yield Pt.	Elas. Limit [1]	Per cent. Elon. In 2 in.	Per cent Reduction
	Lb. per sq. in.				
77674-1	56,075	35,875	29,000	16	23.4
77674-2	58,225	.....	.....	18	27.8

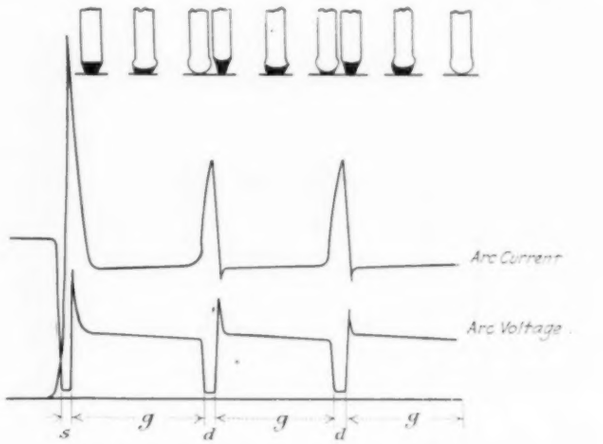

FIG. 2 SEQUENCE OF ARC PHENOMENA

s, start of arc; *g*, growth of liquid globule; *d*, deposition of metal.

The fractures displayed the typical structure of a high-grade, partially annealed, low-carbon cast steel. These values exceed those obtainable from metal deposited by the average welder, and may be used as a "bogie" in the development of both welders and electrodes.

The results of tests on the 14-lb. deposit, formed under conditions analogous to those obtaining on welding a locomotive frame, are given in Table 2.

[3] Some Recent Investigations in Arc Welding, by O. H. Eschholz, Proc. A. I. & S. E. E., December, 1917.

TABLE 2 RESULTS OF TENSILE TESTS ON MATERIAL IN 14-LB. DEPOSIT OF ARC METAL

Tensile Test No.	U. T. S.	Yield Pt.	Elas. Limit [1]	Per cent Elon. in 2 in.	Per cent Reduction
	Lb. per sq. in.				
77,651-1	58,825	41,000	40,000	8.2	19.9
77,651-2	54,650	35,000	29,000	6.5	13.4

Compression Test No.	Elas. Limit, [1] Lb. per sq. in.
77651-1A	29,450
77651-2A	34,500

Brinell Hardness, No. 114.
Transverse: Ultimate, 89,400 lb. per sq. in.; elas. limit,[1] 47,600 lb. per sq. in.; supports, 6 in.; deflection, 0.03 in.
Cantilever: Ultimate, 86,200 lb. per sq. in.; elas. limit,[1] 44,750 lb. per sq. in.; supports, 2 in.; deflection, 0.03 in.
Bending: 100 deg. on 1 in. radius, bar ½ in. thick.
Shear: 46,200 and 44,600 lb. per sq. in.
Impact: Izod, unannealed specimens, 2; 2; 1; ft.-lb.

[1] Elastic limits were obtained by Johnson's method.

These data are typical of the characteristics of arc metal when deposited by a conscientious, skilled welder. Similar results will be consistently obtained only when mechanical engineers demand proper instruction and supervision of welding operators. Further improvement in metal characteristics may be secured by the use of special electrodes and heat treatment.

Physical Properties of Arc-Welded Sections

A weld is formed by the fusion of successive layers of deposited

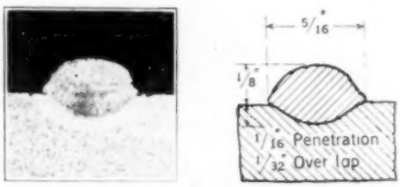

FIG. 3 TYPICAL SECTION THROUGH A LAYER OF ELECTRODE METAL DEPOSITED ON A LOW-CARBON STEEL PLATE WHEN USING A SHORT ARC, 150 AMPERES AND 5/32-IN. BARE ELECTRODE

Note penetration, small overlap at deposit edges, and extent of structural change caused by thermal disturbance.

FIG. 4 SECTIONS MIDWAY THROUGH WELD SHOWING SHANK METAL, ARC-DEPOSITED METAL AND CHARACTER OF FUSION WITH AND WITHOUT THE USE OF A "FREE DISTANCE" AT VEE APEX

metal. The appearance of the section through a single layer fused to a plate surface is shown in Fig. 3, the characteristic contour, penetration and overlap of which may be noted.[4] On welding sections scarfed to a vee opening it is necessary to separate the shank members by a "free distance" of 1-16 in. to ⅛ in. This separation facilitates the fusion of the initial deposited layer to both members, the most important step in fusion welding. In Fig 4, *A* and *B* show respectively sections through plate and deposited metal welded with and without the use of a free distance. In Fig. 4 at *A* fusion is indicated by the irregular line of recession from the original scarfed surface; in the same figure at *B* fusion is shown present only at the top of the joint. The clearance between sections, at the apex of the vee, in this weld, was not sufficient to permit arc formation.

The total thermal energy developed at the fused zones is determined by the arc current employed. It is evident, therefore, that the arc current must be changed with variation in the thermal capacity, thermal conductivity, and temperature of the weld.[5] In Figs. 5, *A* and *B* show sections through welds made with arc currents of 150 and 100 amperes respectively. Fig. 5*A* shows a fracture at a stress approximately 95 per cent of the U. T. S. of the shank metal, while Fig. 5*B* shows a break which occurred during machining. Difference in fusion at scarfed surface and in deposit, homogeneity of metal and character of fracture are marked. Fig. 6 summarizes the results of many tests and indicates the variation in weld strength with arc current for skilled and average welders. Fig. 7 gives suggested current values to be used for various plate thicknesses and electrode diameters. It must be recognized, however, that the position of the plate and any unusual condition affecting thermal factors require other current values.

The data in Table 3 have been selected from tests made by the Bureau of Standards on properly executed bare-electrode arc welds prepared for the Welding Committee of the Emergency Fleet Corporation.[6]

TABLE 3 MACHINED, WELDED SHIP PLATES

Test No.	U. T. S. Lb. per sq. in.	Yield Pt. Lb. per sq. in.	Elon. in 2 in.	Bending 1.5 in. diam. Deg.	Vibration [1]
Original	64,700	38,400	31.5	180	143,753
1	59,800	35,400	9.0	42	845,892
2	62,600	39,000	11.5	44	316,825
5	61,100	35,650	8.5	55	87,762
7	57,600	39,000	8.5	50	41,376

[1] Inconclusive. Fiber stress, 25,000 lb. per sq. in.; r.p.m. = 120; tests made on Upton-Lewis machine.

The characteristic average data shown in Tables 4 and 5 were obtained from tests made for Lloyd's Register of Shipping by David Kirkaldy and Sons, London, on ship plates welded with covered electrodes.

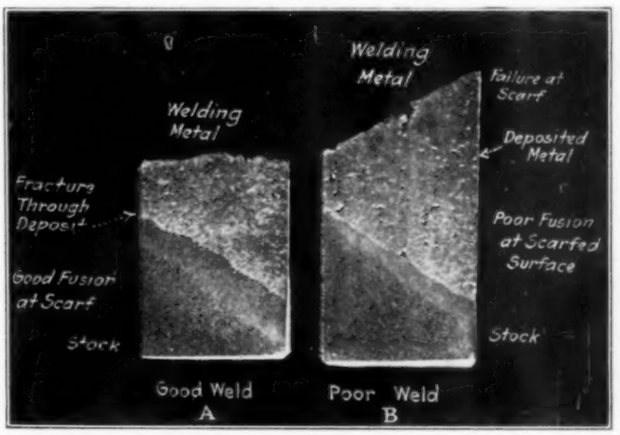

FIG. 5 APPEARANCE OF WELD SECTIONS WHEN USING (*A*) 150 AMPERES ARC CURRENT AND (*B*) 100 AMPERES

TABLE 4 TESTS ON SHIP PLATES WELDED WITH COVERED ELECTRODES

Specimen.	U. T. S. Lb. per sq. in.	Yield Pt. Lb. per sq. in.	Per cent Elong. in 8 in.	Per cent Reduction.	No. of Tests
Unwelded	62,000	.....	28	45	4
Welded plate	60,400	.....	18	35	8
Arc deposited metal	64,500	44,600	13	21	2

TABLE 5 ALTERNATING-STRESS TEST, 1000 R.P.M., ROTATING WELDED BAR ⅝-IN. DIAMETER

Specimen.	Stress at Periphery, Lb. per sq. in.	Rotations.	Remarks.
Unwelded	± 23,500	5,000,000	Fractured
Welded	± 14,000	4,355,000	Fractured
Welded	± 14,000	5,000,000	Unbroken
Welded	± 18,800	5,000,000	Unbroken
Welded	± 18,800	1,705,000	Fractured
Welded	± 20,500	1,510,000	Fractured

[4] A complete discussion of fusion characteristics is contained in a paper by the author on Fusion in Arc Welding, Proc. A. I. E. E., March 1919.

[5] Training of Arc Welders, O. H. Eschholz, *Electrical World,* September 27, 1919, October 4, 1919.

[6] Welding Mild Steel, H. M. Hobart, Proc. A. I. E. E., March, 1919.

While the data in these tables may be typical now of a skilled welder only, nevertheless they indicate the potentialities of the process and the progress to be obtained in welded structures by the development of proficient operators.

CONCLUSIONS

The present status of arc welding may be summarized as follows:

a Mainly utilized for the welding of low-carbon steel members subjected to static tension or compression stresses

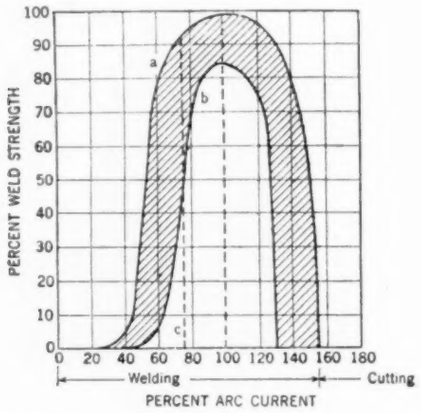

FIG. 6 APPROXIMATE CHANGE IN WELD STRENGTH WITH CHANGE IN ARC CURRENT FOR (*A*) SKILLED AND (*B*) AVERAGE WELDERS

Welders tend, as a rule, to employ a current value approximately equal to 75 per cent, that giving best results. The weld strength, as shown by *c*, will therefore vary from 40 per cent to 90 per cent of maximum, depending on the skill of the operators.

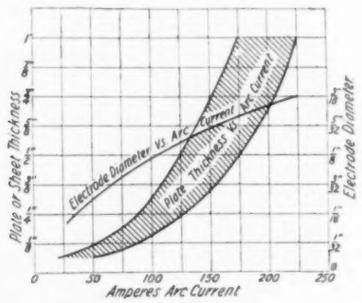
Plate or Sheet Thickness
Electrode Diameter
Electrode Diameter Vs. Arc Current
Plate Thickness Vs. Arc Current
0 50 100 150 200 250
Amperes Arc Current

FIG. 7 RELATION OF APPROXIMATE ARC CURRENTS AND ELECTRODE DIAMETERS

b Production and repair welding of parts wherein possible weld failure will not involve life hazard

c Knowledge of welding phenomena and correct welding procedure is not widely disseminated

d Process control and inspection methods, although practicable, are not enforced.

The trend of future activity appears to be as follows:

a Initiation of training schools having a standardized welding course, in large industrial establishments

b Uniform electrode specifications and tests

c Further determination of physical properties of arc-deposited metal with a resulting continued development in electrode manufacture and process control

d Application of inspection methods

e Introduction of automatic arc welding

f Application to non-ferrous metal welding

g Definition of the limitations of the process in the welding of the various alloys, steels and structures subjected to fatigue stresses.

New York Law Requires Licensing of Engineers

The New York Law for the licensing of professional engineers and land surveyors became effective May 14, 1920. Its administration is in the hands of a board of five licensed engineers appointed by the regents of the University of the State of New York. The personnel of this board has not as yet been named, although it is expected that the appointments will be made on or before October 8. A brief abstract of the law prepared by Engineering Council follows:[1]

APPLICATION FOR CERTIFICATE. Must be made on prescribed form to Regents of the University of the State of New York, Albany, New York. Present practitioners must obtain licenses within two years.

PROFESSIONAL REQUIREMENTS. Law covers all those practicing or offering to practice professional engineering or land surveying.

Experience Without Degree. To practice Engineering—Six or more years of active professional engineering work, one of which shall have been in responsible charge, of a character satisfactory to the board. To practice Land Surveying—Four or more years of active engagement in land surveying work of a character satisfactory to the board.

Educational Allowance. Each two years of study of engineering in a school of engineering of standing satisfactory to the regents considered as equivalent to one year of active practice.

Society Membership. No provision covering membership.

GENERAL REQUIREMENTS. *Citizenship of United States.* To practice Engineering—not necessary. To practice Land Surveying—necessary—or a declaration to become a citizen.

Age. At least 21 years.

Miscellaneous. Must be of good character and repute. To practice Land Surveying, must speak and write the English language.

EXAMINATIONS. *Conditions Under Which Required.* If evidence presented in application does not appear to board conclusive or warranting issuance of a certificate, applicant may present further evidence, which may include the result of a required examination. Nature and frequency of examinations not prescribed.

FEES. For certificate to practice Engineering or Land Surveying—$25. For certificate to practice both Engineering and Land Surveying—$35. For reissuance of lost or destroyed certificate—$1. If issuance of certificate be denied, fee shall be returned.

PUBLIC WORK. Two years after act takes effect, no county, city, town or village, or other political subdivision shall engage in construction or maintenance of any public work involving professional engineering or land surveying for which plans, specifications and estimates have not been made by, and construction and maintenance supervised by, a licensed engineer or land surveyor, provided contemplated expenditure for completed project does not exceed $2000.

SEALS. Each licensee may obtain a seal of design authorized by board, bearing licensee's name and the legend "licensed professional engineer" or "licensed land surveyor." Plans, specifications, plats, and reports may be stamped with said seal.

EXEMPTIONS. *Employees of Licensed Practitioners.* Employees of licensed engineers or licensed land surveyors, so long as practice does not include responsible charge of design or supervision as principal.

Contractors and Superintendents. Not covered by this law.

Federal, State, and Municipal Employees. Employees of state or any political subdivision are exempted from the time act becomes effective only until the then existing term of office expires. Officers or employees of United States entirely exempt.

Corporations or Partnerships may engage in the practice of engineering or land surveying provided person or persons connected with such corporation or partnership in charge of design or supervision which constitutes such practice is or are licensed. Same exemptions as apply to individuals apply to corporations and partnerships.

Overlapping Duties. Engineers not prohibited from making land surveys essential to engineering projects.

RECIPROCITY. *Non-Resident Practitioner* may practice in this state, provided he is legally qualified for such professional service in his own state or country, where the necessary qualifications for which meet the requirements of the board of regents. May be granted a certificate upon payment of the required fee if he holds a like unexpired certificate from another state or territory in the United States in which the requirements for license or registration are of a standard satisfactory to the board.

New Resident. Provided he has filed application for license and has paid required fee, may practice for such reasonable time as the board requires in which to consider and grant or deny application.

REVOCATION OF CERTIFICATE. The regents may revoke a certificate for cause only after a hearing at which the accused has the right to be represented by counsel, to introduce evidence and to examine and cross-examine witnesses.

LEGISLATIVE INFORMATION. Law is Article IV-A of Chapter 25, Laws of 1909. Approved May 14, 1920. Introduced in Senate, No. 1104, by Mr. Ferris, March 17, 1920. Article VII-A, Chapter 25, Laws 1909 applies to registration of architects. Laws of 1915, Chapter 454.

[1] Engineering Council does not guarantee the legal accuracy of this abstract.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

SUBJECTS OF THIS MONTH'S ABSTRACTS

COTTON ROPE FOR POWER TRANSMISSION
HORSEPOWER TABLE FOR POWER TRANSMITTED BY COTTON ROPE
SHEAR STRENGTH OF PLYWOOD WEBS
GEARED TURBINES WITH DOUBLE REDUCTION GEARS
TURBINES ON S.S. *Curriculca*
ALULA WING
DROP-FORGING DEFECTS
STEEL CASTINGS, LIGHT
CORE MAKING FOR STEEL CASTINGS
FUEL FOR ELECTRIC RAILWAYS
SAWMILL REFUSE AS FUEL
HARDENING CARBON STEEL AND RATE OF COOLING
AIR CLASSIFICATION OF PULVERIZED MATERIALS
RAYMOND SYSTEM OF AIR CLASSIFICATION
ZEITLIN VARIABLE-STROKE ENGINE
AIR-COOLED SLEEVE-VALVE ENGINE
BURT SINGLE-SLEEVE VALVE
LAWS OF HIGH-SPEED PUNCHING
ARMOR-PLATE PENETRATION BY PROJECTILES
STAMPS FOR HOT STAMPING
BRITISH AND AMERICAN PRACTICE IN STAMPING COMPARED
TWIST DRILLS, USE AND ABUSE
MORETTI HYDRAULIC TURBINE LATHE
LATHE FOR CRIPPLES, HYDRAULIC
BOWDEN PETROMETER
LANCHESTER CHASSIS AND ENGINE
WATER SOFTENING IN PITTSBURGH

Cotton Rope for Power Transmission

COTTON ROPE FOR TRANSMISSION, J. Melville Alison. General discussion of the subject based primarily on English practice, together with data of practical character on the installation and operation if such transmission.

From the article it would appear that cotton has entirely supplanted manila for transmission work in England, the reason for this being the longevity and high factor of efficiency of cotton rope. In fact, the author cites a case where ropes installed in October, 1879, and doing a 24-hour day's work are still in service. This is claimed to be sufficient to overcome the handicap of the higher initial cost of cotton rope. As regards the type of rope, 3- and 4-strand ropes are the most usual. The general advantage seems to lie with the 3-strand rope, because, as shown in Fig. 1,

FIG. 1 SECTIONS OF 3- AND 4-STRAND COTTON ROPE

an equilateral triangle is obtained by connecting the centers of the strands, demonstrating the triangulation of the strains, which is a principle adopted by engineers in erecting angular constructions such as bridges. With the 4-strand rope and the same method of connecting the strand centers, a square is obtained, which is a less desirable structure. Furthermore, the 4-strand rope cannot be constructed without a supporting core and its collapse must mean the dislocation of the whole structure. The core, however, represents only about 1/40 of the cross-sectional area of the rope, and it must be reasonably assumed that the stresses exerted by the alternate contraction and extension of the spiral as the rope passes over the sheaves must tend toward the breaking up of this core, which actually takes place.

The relative spiral elongation of the two types of ropes is also such as to favor the 3-strand type.

Grooving. In laying out a groove it should be borne in mind that a rope is to all intents and purposes an elastic wedge and reaches its highest driving capacity when it is pressed to the shape of the groove itself. If the sides of the groove are merely tangent to the circle representing a given size of rope, there is a danger of the groove being too shallow, so that when the compression takes place (possibly after a short term of running) the rope is liable to find its way to the bottom of the groove. In this case slipping takes place, the true indication of which is heated sheave rims. Grooves with curved sides are undesirable.

The rope should decide the angle of the groove and not vice-versa. The groove may be set out as shown in Fig. 2.

First set a circle of equal diameter to the rope, draw the vertical and horizontal center lines. The chord of the arc *AB* is then marked off. This becomes the unit measurement and when laid off downward along the vertical line from the center of the circle, indicates the center of the curve of the bottom of the

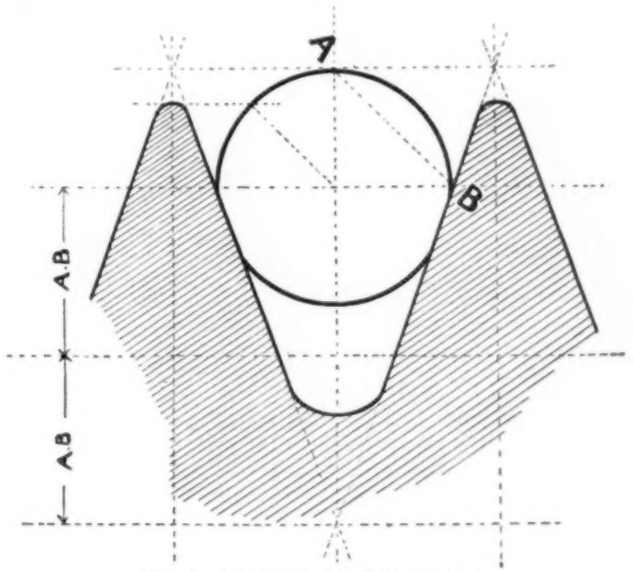

FIG. 2 GROOVING OF COTTON ROPE

groove. Laid off a second time from this center, the apex of the inverted angle of the groove is determined. This angle always comes out at about 40 deg. whatever the size of the rope may be. Extend the lines of the angle through *BB*, cutting off segment of the circle on the way, until they intersect the horizontal dotted line through *A*, which points fix the radii of the mid-flanges. This groove may be taken as a standard for ropes over 1 in. in diameter and also shows the approximate actual compression which takes place in a rope at work.

Fixed and Revolving Ropes. The author is in favor of wedged rope, which with its angular formation makes a better groove contact than the revolving rope. Further, it has less tendency to slippage and a shorter life. Ropes which are underworked will often tend to revolve, a golden rule in rope transmission being that ropes like work to do.

TABLE 1 POWER TRANSMITTED BY VARIOUS ROPES AT VARIOUS SPEEDS

Velocity, ft. per min.	Diameter of Ropes, In.												
	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2
1000	4	6	9	12	15	19	24	28	34	39	46	53	60
2000	4½	7	10½	14	18	23	28	31	37	43	51	58	67
3000	5½	8½	12½	17	22	28	32	36	40	48	56	65	75
4000	...	...	14½	20	26	32	36	40	46	54	64	73	84
5000	...	...	...	23	30	38	43	48	55	64	75	87	98
6000	...	...	...	...	35	44	52	58	68	78	92	105	117
7000	...	...	...	...	...	...	62	70	84	98	114	131	144

Life of the Rope. All things being equal, durability may be gaged by sectional area. The most economical diameters range from 1½ to 1¾ in., although for rolling-mill work 2-in. ropes are generally used.

Cases are mentioned of cotton ropes having a life of 28 to 40 years. Such cases of longevity lead to the conclusion that well-made cotton ropes are not readily subject to fatigue and have a power of quick recovery, which latter is said to be due to the fact that the ropes pull down on the working side and bulge out to their normal diameter immediately upon passing to the idle or slack side of the drive

English and American Systems. In England the ropes are handled under the multiple system; in America, by the continuous method. The advantage claimed for the English system is immunity from stoppage, since it is seldom that more than one rope gives way at a time.

Center Distance. It would appear that driving may be successfully accomplished, even where sheaves are almost touching, by using enough rope. A case is mentioned where sheaves are so close that a finger would scarcely pass between them.

Over- and Under-Driving. It is generally accepted that the slack side of the drive should come on top, but this is not universally so. With an erratic or fluctuating load such as obtains in rolling-mill practice, it is recommended to have the slack on the bottom, as this minimizes the tendency of the rope to wander from its appointed track. Sometimes, however, ropes persist in wandering, in which case the erection of a rope guard in comb fashion is recommended. This practice is common in England.

Sheave Diameters. In England the minimum standard is taken as approximately 30 times the diameter of the rope—in America forty to fifty times. This, however, is largely a question of speeds to sheave size, as for instance a ½-in. rope will run comfortably over a 4-in. sheave at 1000 r.p.m., a 1-in. rope over a 22-in. sheave at 3000 r.p.m., and it is only when the speed rises to 5000 ft. per min. that we meet the 30-times rule for 1-in. rope.

Centrifugal Force. The effect of centrifugal force in rope driving appears to be different from that in belt driving. In this connection Table 1 is of interest, as it would indicate that higher speeds do not detract too much from the ability to transmit power. Cases are mentioned of drives in England and France running at over 7000 ft. per min. and transmitting the highest calculated horsepower. In Cleveland, England, there is a case where the ropes are running at 7800 ft. per min. The driving sheave is 14 ft. 4 in. in diameter, making 168 r.p.m.; the driven sheave is 4 ft. 7 in. diameter, with nineteen 2-in. ropes to transmit 1400 hp. The driven sheave only shows a diameter 27.5 times that of the rope, but is giving comparatively good service.

As regards the effect of moisture, it is stated that cotton ropes are less susceptible to atmospheric changes than manila for the reason that in the first the moisture has a better chance for evaporation. This renders cotton rope practically immune from internal mildew which so often is to be found in discarded manila rope.

As regards the arc of contact, formulæ are given in the original article showing methods of proportioning the pulleys for the two cases of slack above and slack below.

Splicing. The subject of splicing is so important to the well-being of the system in general that, rather than have installations spliced by indifferent workmanship, expert splicing mechanics are sent out from England to all parts of the world. Experiments have been carried on with different devices of metal and other couplings with a view to dispensing with splicing, but nothing has yet been found which, in England, would be considered against the long splice. This is usually calculated at about 82 times the diameter of the rope.

Horsepower. Attention is called to Table 2, giving horsepower transmitted by good 3-strand cotton driving rope. (*Journal of The Engineering Institute of Canada*, vol. 3, no. 6, June 1920, pp. 292-298, 10 figs.)

TABLE 2 HORSEPOWER TRANSMITTED BY GOOD 3-STRAND COTTON DRIVING ROPE

Rope Veloc., ft. per min.	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.	1⅜ in.	1½ in.	1⅝ in.	1¾ in.	1⅞ in.	2 in.	Rope Veloc., ft., per min.	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.	1⅜ in.	1½ in.	1⅝ in.	1¾ in.	1⅞ in.	2 in.
1000	1.0	1.6	2.3	3.2	4.2	5.3	6.6	8.0	9.5	11.2	13.0	14.9	17.0	3600	...	...	7.7	10.8	13.8	17.5	21.7	26.1	31.3	36.5	42.6	49.1	55.6
1100	1.2	1.8	2.6	3.6	4.7	5.9	7.4	8.9	10.6	12.5	14.5	16.7	19.0	3700	...	...	7.8	11.0	14.0	17.8	22.0	26.5	31.8	37.1	43.2	49.9	56.4
1200	1.3	2.0	2.9	4.0	5.2	6.5	8.1	9.8	11.7	13.8	16.0	18.5	20.9	3800	...	...	7.9	11.1	14.2	18.1	22.3	26.9	32.2	37.7	43.8	50.7	57.2
1300	1.4	2.2	3.2	4.4	5.7	7.1	8.8	10.7	12.8	15.1	17.5	20.2	22.8	3900	...	...	8.0	11.2	14.4	18.3	22.6	27.3	32.6	38.3	44.4	51.4	58.0
1400	1.5	2.4	3.5	4.8	6.2	7.7	9.5	11.6	13.9	16.3	18.9	21.9	24.7	4000	...	...	8.1	11.3	14.6	18.5	22.9	27.7	33.0	38.8	45.0	52.1	58.8
1500	1.6	2.6	3.8	5.2	6.7	8.3	10.2	12.5	15.0	17.5	20.3	23.5	26.5	4100	...	...	...	11.4	14.8	18.7	23.2	28.1	33.4	39.3	45.5	52.7	59.6
1600	1.7	2.8	4.1	5.5	7.1	8.9	10.9	13.4	16.0	18.7	21.7	25.0	28.3	4200	...	...	...	11.5	15.0	18.9	23.5	28.4	33.8	39.8	46.0	53.3	60.3
1700	1.8	3.0	4.4	5.8	7.5	9.5	11.6	14.2	17.0	19.9	23.1	26.5	30.1	4300	...	...	...	11.6	15.2	19.1	23.8	28.7	34.2	40.2	46.5	53.9	61.0
1800	1.9	3.2	4.6	6.1	7.9	10.1	12.3	15.0	18.0	21.0	24.4	28.0	31.8	4400	...	...	...	11.7	15.4	19.3	24.1	29.0	34.6	40.6	47.0	54.4	61.7
1900	2.0	3.4	4.8	6.4	8.3	10.7	13.0	15.8	18.9	22.1	25.7	29.5	33.5	4500	...	...	...	11.8	15.6	19.5	24.4	29.3	35.0	41.0	47.5	54.4	62.3
2000	2.1	3.6	5.0	6.7	8.7	11.2	13.4	16.6	19.8	23.2	27.0	31.0	35.2	4600	...	...	...	11.9	15.8	19.7	24.7	29.6	35.4	41.4	48.0	55.4	62.9
2100	2.2	3.8	5.2	7.0	9.1	11.7	14.4	17.3	20.7	24.3	28.2	32.5	36.8	4700	...	...	...	12.0	16.0	19.9	24.9	29.9	35.8	41.8	48.5	55.9	63.5
2200	2.3	3.9	5.4	7.3	9.5	12.2	15.1	18.0	21.6	25.0	29.4	33.9	38.4	4800	...	...	...	12.1	16.2	20.1	25.1	30.2	36.1	42.2	49.0	56.4	64.1
2300	2.4	4.0	5.6	7.6	9.9	12.7	15.7	18.7	22.5	26.5	30.6	35.3	39.9	4900	...	...	...	12.2	16.3	20.3	25.3	30.5	36.4	42.6	49.5	56.9	64.7
2400	2.5	4.1	5.8	7.9	10.3	13.2	16.3	19.4	23.3	27.5	31.8	36.6	41.4	5000	...	...	...	12.3	16.4	20.5	25.5	30.8	36.7	43.0	50.0	57.4	65.3
2500	2.6	4.2	6.0	8.2	10.7	13.7	16.9	20.1	24.1	28.5	32.9	37.9	42.9	5100	...	...	...	...	16.5	20.7	25.7	31.1	37.0	43.4	50.4	57.9	65.9
2600	2.7	4.3	6.2	8.5	11.1	14.1	17.4	20.8	24.9	29.4	34.0	39.1	44.4	5200	...	...	...	...	16.6	20.9	25.9	31.4	37.3	43.8	50.8	58.4	66.4
2700	2.8	4.4	6.4	8.8	11.4	14.5	17.9	21.5	25.7	30.3	35.1	40.3	45.8	5300	...	...	...	...	16.7	21.1	26.1	31.7	37.6	44.2	51.2	58.9	66.9
2800	2.9	4.5	6.6	9.1	11.7	14.9	18.4	22.2	26.5	31.1	36.1	41.4	47.1	5400	...	...	...	...	16.8	21.3	26.3	32.0	37.9	44.6	51.6	59.4	67.4
2900	3.0	4.6	6.8	9.4	12.0	15.3	18.9	22.8	27.2	31.9	37.1	42.5	48.4	5500	...	...	...	...	16.9	21.5	26.5	32.3	38.2	45.0	52.0	59.9	67.9
3000	3.1	4.7	7.0	9.6	12.3	15.7	19.3	23.4	27.9	32.7	38.0	43.6	49.6	5600	...	...	...	...	...	21.7	26.7	32.5	38.5	45.3	52.4	60.3	68.4
3100	...	4.8	7.2	9.8	12.6	16.0	19.7	23.9	28.5	33.4	38.9	44.6	50.7	5700	...	...	...	...	...	21.9	26.9	32.7	38.8	45.6	52.8	60.7	68.9
3200	...	4.9	7.3	10.0	12.9	16.3	20.1	24.4	29.1	34.1	39.7	45.6	51.8	5800	...	...	...	...	...	22.1	27.1	32.9	39.1	45.9	53.2	61.1	69.4
3300	...	5.0	7.4	10.2	13.2	16.6	20.5	24.9	29.7	34.7	40.5	46.5	52.8	5900	...	...	...	...	...	22.2	27.3	33.1	39.4	46.2	53.6	61.5	69.9
3400	...	5.1	7.5	10.4	13.4	16.9	20.9	25.3	30.3	35.3	41.2	47.4	53.8	6000	...	...	...	...	...	22.3	27.5	33.3	39.6	46.5	54.0	61.9	70.4
3500	...	5.2	7.6	10.6	13.6	17.2	21.3	25.7	30.8	35.9	41.9	48.3	54.7														

Shear Strength of Plywood Webs

Shear Strength of Plywood Webs. Tests were conducted by the Forest Products Laboratory, Madison, Wis., to determine the shearing strength of plywood and laminated veneer webs and to determine the influence of the strength of various factors such as the number of plies, the thickness of the various plies, the relative direction of the grain in the plies, the distance between the shearing forces, the length of shearing section and the direction of the shearing forces relative to the grain of the wood.

The tests were divided into two series. The test specimens were either clamped or glued between two pairs of posts to which the load was applied. The distance between the shear forces was varied from ¼ in. to 6 in., so that the specimens were not subjected to true shear but to a combination of shear and flexural stresses.

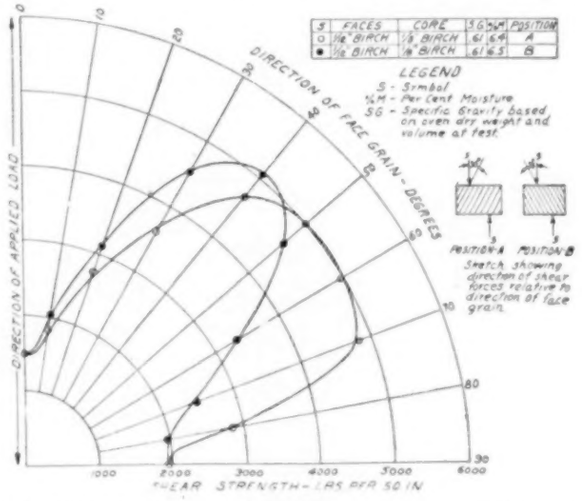
S | FACES | CORE | SG | %M | POSITION
○ | 1/8" BIRCH | 1/8" BIRCH | 61 | 6.4 | A
● | 1/8" BIRCH | 1/8" BIRCH | 61 | 6.5 | B
LEGEND
S - Symbol
%M - Per Cent Moisture
SG - Specific Gravity Based on oven dry weight and volume at test
POSITION A
POSITION B
Sketch showing direction of shear forces relative to direction of face grain.
DIRECTION OF APPLIED LOAD
DIRECTION OF FACE GRAIN - DEGREES
SHEAR STRENGTH - LBS. PER SQ IN

Fig. 1 Relation between Unit Shear Strength of 3-Ply Wood and Direction of Grain

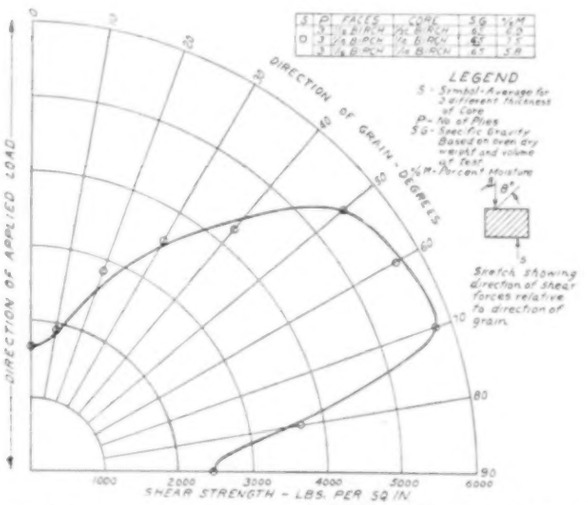
S | PLIES | FACES | CORE | SG | %M
LEGEND
S - Symbol - Average for 3 different thicknesses of Core
P - No. of Plies
SG - Specific Gravity Based on oven dry weight and volume at test
%M - Percent Moisture
Sketch showing direction of shear forces relative to direction of grain.
DIRECTION OF APPLIED LOAD
DIRECTION OF GRAIN - DEGREES
SHEAR STRENGTH - LBS. PER SQ IN

Fig. 2 Relation between Unit Shear Strength of Parallel-Ply Laminated Veneer and Direction of Grain

The results of the tests are given in tables and curves. The tests indicate that the shear strength of 3-ply wood of various species, having all plies of one panel of the same thickness and species, is somewhat greater across the face grain than parallel to the face grain.

The unit shear strength of 3-ply birch plywood within the limits of thicknesses tested is slightly less than that for wood having five or more plies.

The unit shear strength of 3-ply wood perpendicular to the face grain and parallel-ply laminated veneer, both perpendicular and parallel to the grain, decreases with an increase in the distance between the shear forces.

The unit shear strength of birch plywood perpendicular to the face grain within the limits of the experiments decreased with an increase in the ratio of the core to total panel thickness.

The maximum shear strength of plywood and of laminated veneer having the grain of all plies parallel is obtained with angles of from 40 to 70 deg. and from 50 to 70 deg., respectively, between the direction of the applied force and the face grain. This shear strength at the optimum angle is usually more than twice that of the shear strength parallel or perpendicular to the face grain. (Figs. 1 and 2.) In Fig. 1 the two curves show the results obtained on 1/12-1/8-1/12-in. birch plywood for each of the two positions in which the specimen may be tested for each angle between face grain and direction of applied load. In other words, the two points for a given angle represent the unit shear strength of the plywood with shear forces in opposite directions.

The data determine that the shear strength of plywood is dependent, in general, upon the specific gravity of the species; and the higher the specific gravity the greater will be the shear strength.

These tests have confirmed the existence of an important difference between plywood and ordinary wood in shear, namely, the nature of the failure. Ordinary wood fails suddenly and completely. In the case of plywood, the failure is more gradual and less complete, as in plywood under shear the plies fail first in shear along the grain but the failures in successive plies are at right angles to each other.

The shear strength of plywood and parallel-ply laminated veneer, as shown in Figs. 1 and 2, is dependent to a very large extent upon the direction of the shear forces relative to the face grain. (Engineering Division, Air Service, McCook Field, *Technical Orders*, No. 14, March 1920, pp. 47-60, 6 figs., *epA*. Abstracted by special permission of the Office of the Director of Air Service, War Department)

Geared Turbines with Double-Reduction Gear

Geared Turbines With Double-Reduction Gear. For the S.S. *Corrientes*, the Parsons Marine Steam Turbine Co. has designed a turbine installation with several novel features.

The total horsepower which the turbines are designed to develop is only 3000 hp., and yet there are three ahead turbines arranged in series, and two astern turbines fitted respectively within the low-pressure and the intermediate-pressure casings. (Fig. 1A.)

The arrangement of gearing is unusual. The high-pressure and intermediate-pressure turbines (Fig. 1B) both engage with one wheel; the intermediate-pressure turbine being arranged vertically above this wheel. The low-pressure turbine engages with a second wheel on the opposite side of the propeller shaft. Fig. 1C shows the arrangement of the gear box.

In the turbines themselves dummies are absent, the thrust being taken on Michell blocks as shown in Fig. 1C. Carbon glands are used for the high-pressure and intermediate-pressure turbines. The elimination of the dummies reduces to quite low values certain leakage losses which have hitherto served to limit the commercial efficiency of the smaller sizes of the Parsons type of turbine.

The theoretical stage efficiency of a reaction turbine is higher than that of an impulse turbine since each row of blades, whether fixed or moving, constitutes a pressure stage, and the losses in a

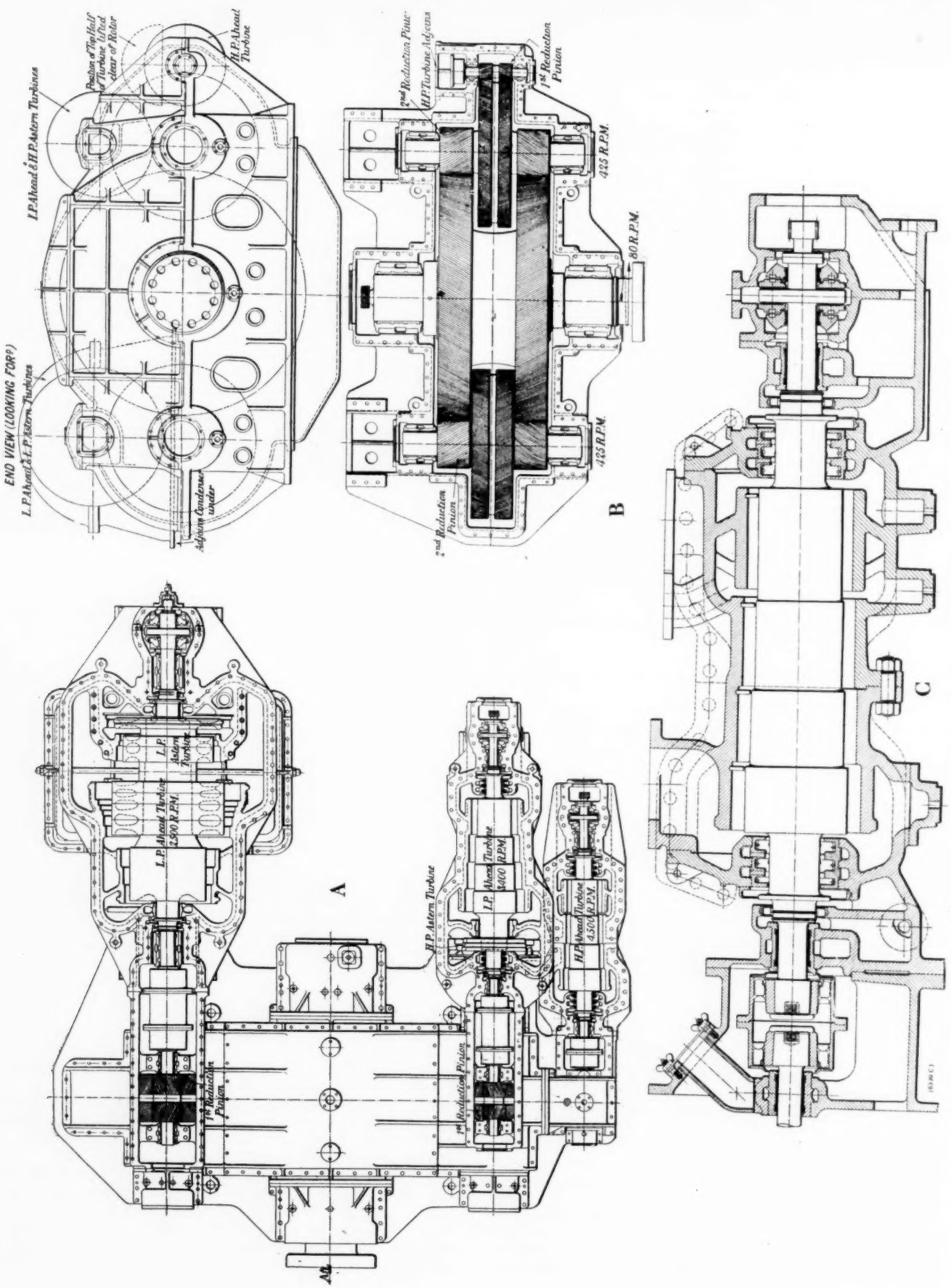

FIG. 1 PARSONS GEARED TURBINES WITH DOUBLE REDUCTION GEAR ON S. S. *Corniches*

pressure stage thus consist of nozzle friction only, while in each pressure stage of an impulse turbine the bucket losses must be added to the nozzle losses. As a consequence, it is a noteworthy fact that in water-turbine practice the efficiency of the reaction machine is not less than of the impulse type, although the latter is generally free from the leakage losses and the disk friction which are unavoidable with steam turbines of the same type. It is obvious, therefore, that the intrinsic efficiency of the reaction blading is higher than that of impulse blading, but in the past this has been counteracted by the larger leakage losses. It is to reduce these that the dummies have been eliminated and in a further effort in the same direction the "end-tightening" principle has been applied to the high-pressure blading. With this system the turbine is assembled and driven in the shops with no clearance at all at the high-pressure blading, which is thus worn to a uniform bearing and the working clearance is then adjusted to about one-half of the radial clearance which would otherwise be necessary.

The blading is shrouded and the shrouding taken off to a thin edge which abuts on the foundation ring at the root of the following or preceding row of blades. The rotor spindle is adjustable axially and thus the thin edge of the shrouding can be brought into actual contact with the opposing surfaces.

If the turbine is started up in this state it will wear its own clearances, which are therefore as small as could be. It is said that no trouble is experienced from the heat generated by the friction during this period of wear, this being explained by the mechanical principle said to be first formulated by Sir Charles Parsons, namely, that when two unlubricated surfaces are in relative motion and are liable to touch, one of the surfaces should be reduced to a mere fin which is insufficiently rigid to cause distortion of other parts by being heated and is too light to produce much heat through its wearing away.

It is claimed that this type of turbine is particularly adapted for working with superheated steam. The rotors, though of small diameter, are short and stiff, while the use of the end-tightened blading makes large radial clearances possible in the region where the steam temperature is high. (*Engineering*, vol. 110, no. 2850, Aug. 13, 1920, pp. 211, 212, 214 and 2 sheets of plates, 7 figs. besides the plates, *dA*)

Short Abstracts of the Month

AERONAUTICS (See also Internal-Combustion Engineering; Measuring Instruments)

ALULA WING. Data on the Alula wing developed by the Blackburn Aeroplane Co. and used in the Pelican 4-ton air truck of the Commercial Aeroplane Wing Syndicate, Ltd.

The Alula wing is claimed to be a new wing type. It is stated that a method of designing a concrete wing shape was evolved enabling the designer to vary all features of a wing in unison

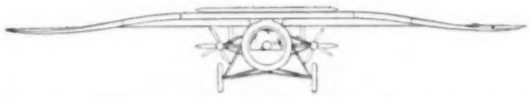

FIG. 1 PELICAN 4-TON AIR TRUCK WITH ALULA WING

whenever a particular one had to be changed, in such a manner as not to upset their interrelation. No data as to the mathematical method referred to are, however, presented beyond general statements. Fig. 1 may give some indication as to the character of this wing. (*Aeronautics*, vol. 19, no. 354, July 29, 1920, pp. 96-97, 3 figs., *dg*)

ARTILLERY (See Machine Shop)

AUTOMOTIVE ENGINEERING (See Measuring Instruments)

FORGING

DEFECTS IN DROP FORGINGS, P. Rowley. Rejected drop forgings may owe their rejection to defects in the steel from which they are made. If a billet has a crack or lap which is oxidized inside, the chances are that it will extend during working, especially if the metal is spread by a peg in the die. Cracks which do not open during forging may extend during the oil and water quenching. Piping and ghost lines are also found to be a source of trouble.

Some troubles of the drop forger may be due also to segregation in the metal, especially in alloy steel, of which segregation there are several types. In one case of 3 per cent nickel-chrome steel worked up into connecting rods trouble was encountered during machining. Investigation showed that while the outer layer of a rod cut through the center longitudinally had a carbon content of 0.37 per cent, the inner part approximated to 1 per cent, the segregation of carbon being apparently due to the method adopted by the steel maker to prevent piping. Some of the troubles in drop forging are due to improper design of the parts, traceable to lack of drop-forge knowledge on the part of the designers and draftsmen. These people sometimes fail to differentiate between the flow of a molten metal and the flow of a plastic but at the same time a solid material. In casting, metal may flow from two directions into the same part of the mold to form a solid mass on cooling, but plastic metal cannot run together from two directions to form a good forging owing to the oxidation and decarburization of the exposed surfaces. In this connection, the usual H-section connecting rod as commonly used in internal-combustion engine work is cited as an example of a design but poorly suitable for drop forging. The remedy would be to enlarge the radius in the flute so that the metal might run into the sides of the H-section before flowing into the flash. The adoption of a fish-back design of connecting rod wherever possible would result in saving in die manufacture. (Paper before the Association of Drop Forgers and Stampers at Birmingham, abstracted through *Engineering*, vol 110, no. 2849, Aug. 6, 1920, pp. 185-186, *p*)

FOUNDRY

British Practice in Light Steel Casting

LIGHT STEEL CASTINGS, R. J. Dunderdale. This type of casting was not extensively used in England prior to the war, one of the reasons for it being that the small converters which were then a source of steel for this type of work did not produce an entirely suitable metal. The situation, however, has become entirely different with the introduction of the electric furnace.

The types of furnace chiefly in use in England for light steel castings are the Schneider, Heroult and Electro-Metals in sizes varying from ½ ton to 15 tons at a charge. The size suitable for general work in castings ranging from 14 lb. to 140 lb. in weight is the 2-ton furnace, but even then it is desirable to have the furnaces graduated in sizes and used near the type of casting which they would be chiefly employed on.

The sand required for this type of molding differs materially from the usual iron foundry sand. Its physical condition should be hard, sharp and not easily friable. Chemically, it should contain 97 to 98 per cent of silica and as little matter of other kinds as possible. The sand itself should not pass through an 80-mesh screen as its texture will be rendered decidedly finer than this by the clay used for bonding. The best clays for this purpose contain about 30 per cent of alumina and as little organic matter as possible, (a certain amount of iron is said to be an advantage). The moisture of the final mixture which must be good can be as much below 4 per cent as will allow the sand to hold together well.

Baking the mold and painting it with tar from time to time used to be common practice prior to the war. As a matter of fact, however, for a vast majority of light steel castings now made a green mold is entirely satisfactory. A baked mold is still used, however, for very thin work and cored pressure work, providing the mold is made suitably weak and well vented.

A good deal of trouble is experienced from blowholes when the molding is not right, and, in this connection it is stated that the practice of piling is probably not so successful as might be expected, owing to the steam generated in the lower molds getting into the upper molds before the steel does and preventing the exit of gases. This same trouble is apt to occur when two patterns are cast separately in the same box.

Core making in a light-steel-castings foundry has now become a very important part of molding. As regards the sand used in core making, one similar to but rather finer than the facing sand for the molds is desirable.

The causes of the more important failures in light steel castings are discussed in some detail. The three main causes mentioned are short-run castings, slag, and blown and spongy castings.

For repetition work on light steel castings the jolt-ramming type of machine appears to be particularly suitable. In a steel casting it is essential that the face should be hard and the backing moderately weak, in order that the high temperature of the metal and its weight should not break up the face in the first place and the slower-cooling portions shall not be drawn apart by a mold which is uniformly too tightly rammed. The jolt-ramming machine provides this.

As regards fettling, the usual tumbling boxes have not been found sufficient for the hard burning on which takes place in the case of a steel casting, especially in the angles and curves of intricate specimens. Sand blasting has to be resorted to, preferably with steel shot and nozzles.

The development of the light casting industry in England faces the competition of Switzerland, Belgium and Germany, where the same industry appears to be quite firmly established. At present the rate of exchange is in favor of England and it is stated that the future of the industry should be good for some years to come in any event, but there are several weak spots which are apt to be uncovered when competition begins to arise. As a way to help establish this young industry while it is now in a healthy infancy, it is recommended that the light steel castings users combine with the present manufacturers and arrange to parcel out the work to these manufacturers in such a way that one firm is only engaged on two or three standard types of job, this covering the field of repetition work. With regard to the jobbing work, any small quantities of this type should be reserved entirely for two or three foundries suitably equipped with proper range of furnaces. (*Engineering*, vol. 110, no. 2849, Aug. 6, 1920, pp. 167-168, *p*)

FUELS AND FIRING

Sawmill Refuse as Fuel for Electric Railways

FUEL SELECTION FOR ELECTRIC RAILWAYS, Darrah Corbet. Data of tests and experience with sawmill refuse as used for fuel by the Portland Railway Light and Power Company of Portland, Ore.

Sawmill refuse ranging from fine sawdust to large blocks of hardwood, at least 1 ft. square, is available for fuel in power stations in many sections of the country, particularly in the Northwest.

It has a fairly high heating value (8500 B.t.u. per lb. of dry non-resinous wood) and can be readily stored for a considerable length of time without very material depreciation in the fuel value and without involving great fire risk. Moreover it can be fed into furnaces not primarily designed for this kind of fuel, although it is probable that better efficiency could be secured with special furnace design.

The original paper gives curves of comparative values of wood and fuel oil (evaporation from and at 212 deg.), Fig. 2. The use of this curve is based on the assumption of oil at $1 a barrel and 12 lb. of evaporation per pound of oil; sawmill-refuse fuel containing 45 per cent moisture and weighing 20 lb. per cu. ft. and efficiency 60 per cent.

Starting with the value of 12 lb. of evaporation per pound of oil, directly above this at the point of intersection with the line indicating the pounds of oil per barrel, we note that on the left the total evaporation per barrel of oil is 4080 lb. Transferring this below 4080 lb. evaporation across to the right, we note that over the figure $1 per barrel the cost of 1000 lb. of steam is about 24¼ cents.

Starting again with 45 per cent moisture in the sawmill fuel and going to the left to the point of intersection of 60 per cent efficiency, we note that the evaporation per pound of wood is approximately 2.3 lb. water, or with 4000 lb. per unit this is equivalent to about 9200 lb. of water per unit of fuel. Carrying this to the right to the point of intersection with the line indicating cost of steam 24½ cents per 1000 lb., we note $2.25 as the equivalent cost of a unit of fuel.

On the same basis, if oil cost $2 a barrel the equivalent cost of sawmill refuse would be twice the above, or $4.50 a unit. In this manner a ready reference is secured and the curve can probably be read far more accurately than will be the assumptions made.

The use of powdered coal in several power stations in the Northwest is discussed. At the plant of the Pacific Coal Company at Renton, Wash., a large amount of sludge coal accumulated during the past 15 years. In its present form this fuel is practically useless, but after being pulverized is said to give an average evaporation of 5 lb. of water per pound of coal.

It is also stated that the Milwaukee Electric Railway and Light Company has decided to install a powdered-coal burning equipment for a new 40,000-kw. station.

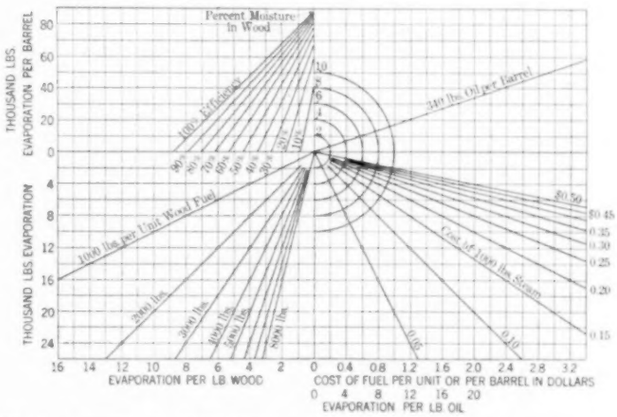
Percent Moisture in Wood
THOUSAND LBS. EVAPORATION PER BARREL
THOUSAND LBS EVAPORATION
1000 lbs per Unit Wood Fuel
2000 lbs.
3000 lbs.
4000 lbs.
5000 lbs.
6000 lbs.
340 lbs Oil per Barrel
Cost of 1000 lbs Steam
EVAPORATION PER LB WOOD
COST OF FUEL PER UNIT OR PER BARREL IN DOLLARS
EVAPORATION PER LB OIL

FIG. 2 CURVES OF COMPARATIVE VALUES FOR WOOD AND OIL FUEL (EVAPORATION FROM AND AT 212 DEG. FAHR.)

On the whole, the author comes to the conclusion that the use of oil fuel will probably be curtailed and more consideration will be given to coal. There is a limited field for sawmill refuse, but better and more efficient means of handling and burning it are desirable. (*Journal of the American Institute of Electrical Engineers*, vol. 39, no. 8, August 1920, abstracted pp. 715-732, 4 figs., 12 tables. Also abstracted in *Electric Railway Journal*, vol. 56, no. 7, Aug. 14, 1920, pp. 314-315, 1 fig., *cp*)

ENGINEERING MATERIALS

French Investigation on the Hardening of Carbon Steel

INFLUENCE OF THE VELOCITY OF COOLING ON THE HARDENING OF CARBON STEEL, Portevin and Garvin. The operation of hardening which consists essentially in a more or less rapid cooling from a temperature T (which may be called the temperature of hardening) depends only on the following two variables: (1) the state of the metal at the beginning of the cooling, that is, the temperature T; and (2) the law of cooling. It is the law of cooling that the authors discuss in the present paper.

This law of cooling for a given steel depends on the following factors:

A—Temperature at the beginning of cooling, T

B—Mass, shape and dimensions of the piece of steel treated

C—Location of the point under consideration in the piece of steel

D—Nature of the bath, that is, the medium by which cooling

is brought about. The action of this medium in its turn depends on its physical properties, namely, its specific heat, its latent heat of vaporization, heat conductivity and viscosity

E—Temperature of the bath, which may vary during the process of cooling depending on the relative masses of the bath itself and of the piece of metal immersed therein

F—Stirring of the bath with respect to the piece of metal

G—State of the surface of the metal piece

H—Temperature at the end of the cooling, or temperature at withdrawal from bath.

For a given point in the piece of metal this law of cooling is completely determined by a curve expressing $\theta = f(t)$, which gives the variation of the temperature θ as a function of the time t. For similar laws of cooling this curve is sufficiently determined by the average velocity of cooling between two given temperatures or by its inverse, namely, the time necessary to traverse a given interval of temperature. The writers adopted as a characteristic value of the velocity of cooling the time necessary for the temperature to change from 700 deg. cent. to 200 deg. cent. which they denote by τ (700-200), or simply by τ.

The paper investigates the following two questions: First, How does the law of refrigeration, or, in other words, the value of τ, vary in accordance with the variation in the factors enumerated from A to H and second, What relation exists for a given steel and a given initial temperature of the process between τ and the final state of the steel as determined by the hardness and the micrographic aspect thereof?

The original paper gives the data secured in the form of curves and tables. Only the most important results obtained in this interesting investigation can be reported here.

It has been found that there is a critical region for the velocity of cooling within which the thermal phenomenon denoting the internal transformations in the steel suddenly changes its character and position in the scale of temperatures. The authors call it the critical velocity of hardening in predetermined conditions defining the initial state of the metal and the law of cooling. The following notation is introduced. Ar′ is the anomalous state very clearly defined on the curves at about 650 deg. cent., and Ar″ a change in the shape in the curves occurring around 300 deg. cent. The transformation denoted by Ar′ and occurring around 650 deg. cent. corresponds to the formation of troostite, and the transformation at the lower temperature Ar″ corresponds to the formation of martensite.

There is therefore a critical velocity denoting the passage from troostitic hardening to martensitic hardening. A parallel phenomenon is observable in measuring hardness. There, there are two regions—one of great hardness around 600 Brinell units and the other of medium hardness around 400 Brinell units. These the authors call martensitic hard hardening and troostitic soft hardening.

Extensive data are presented to show the distinction between these two states.

As regards the influence of the chemical composition on the critical velocity of hardening, the authors claim that this critical velocity is at its minimum when the steel is in the neighborhood of the eutectic. Manganese plays an important role from the point of view of critical velocity, and, for example, a sample of steel with 1.10 per cent of carbon and 0.40 per cent of manganese has a martensitic type of hardening, while a similar sample with 1.07 per cent carbon and 0.08 manganese gave a troostitic hardening.

As regards the rate of cooling approaching the critical rate of hardening, the authors claim that the apparent contradictory behavior observed by various experimenters in reference to the influence of the temperature of cooling may be explained by the difference in the size of the sample on which observations were made. If the sample is small or if the examination is limited to the surface of the sample it will be found that the temperature of hardening has no material influence on the result, because under these conditions the process is always carried on at a rate of cooling considerably below the critical. On the contrary, if the sample is large or the interior is taken into consideration and conditions approaching the critical velocity have been reached, a very different conclusion as to the influence of temperature must be arrived at. If the size of the sample and conditions of cooling are such that at the center of the sample soft troostitic hardening takes place, there is, naturally, between the center and the surface a region martensitic-troostitic in which the critical rates have been exceeded. The location of this region shifts with the initial temperature of hardening, and the thickness of the zone of hard martensitic hardening varies. This is why the temperature of hardening becomes of importance as it affects the penetration of the hard hardness and the hardening of large pieces.

The other parts of this very interesting paper cannot be abstracted because of lack of space.

Among the conclusions attention is called to the following statement: If, with the same steel and the same initial temperature of cooling the rate of cooling is increased, the lowering of the point of transformation does not occur in a regular manner and there is a discontinuity or at least a variation of a non-gradual character in the location of the point of transformation on cooling. After the point of transformation has gone down gradually, the anomaly on cooling passes from the position Ar′ to the position Ar″; whence the notion of *critical velocity of hardening*.

As a matter of fact, this expression "critical velocity of hardening" is not precise and should be replaced by the designation of the critical zone of the velocity of hardening, taking into consideration the phenomenon of the presence of a double point of transformation which leads to the appearance of troostite and martensite.

For carbon steel 350 deg. cent. appears to be the upper limit of temperature at the withdrawal from the bath in case of repeated hardenings or for medium hardness. Such a temperature will not cause a marked decrease of hardness other than that brought about by the slight anneal occurring during the second period of the operation. (*Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, vol. 132, no. 3, May-June 1920, pp.

HANDLING OF MATERIALS

Comparison of Separation of Pulverized Materials by Screens and Air Currents and Description of Raymond System

AIR CLASSIFICATION OF PULVERIZED MATERIAL, S. B. Kansowitz. The means employed to classify pulverized or ground material have so far been screens or air currents. It is the latter which is described here.

The use of screens or screening cloth is claimed to be limited to a comparatively coarse product. When very fine separation is attempted the screens tend to clog, decreasing the capacity and returning to the mill tailings which contain a high percentage of fine particles. With hard abrasive material the screen openings are rapidly enlarged and then give a product coarser than desired.

Air separation is claimed to avoid all these difficulties. A real air separator should be an integral part of the mill and should be able to remove the ground material from the grinding surfaces as fast as produced. This can be accomplished only by having the air enter underneath the grinding surfaces and blow the ground particles up and away from the rolls.

The separator should be dustless in operation and capable of maintaining uniform product under all reasonable changes of air velocity and air density. Furthermore, it should be so designed that fineness of the finished product could be changed on short notice and without shutting down the equipment.

Figs. 3 and 4 show cross-sections of the Raymond system of air classification. The material from the grinders is drawn into a fan and then blown into a cyclone dust collector. After traveling in the comparatively small-sectioned discharge pipe the material enters the large collector and is compelled to travel in a circular path. The centrifugal force thus produced causes the material to hug the walls of the collector and eventually drop through the bottom as finished product. The air freed from the material passes off through the top of the collector into the return air pipe which delivers the air back to the port holes under the grinding chamber. These ports are surrounded with an air-tight casing. In the separator the whirling currents travel in a larger and larger

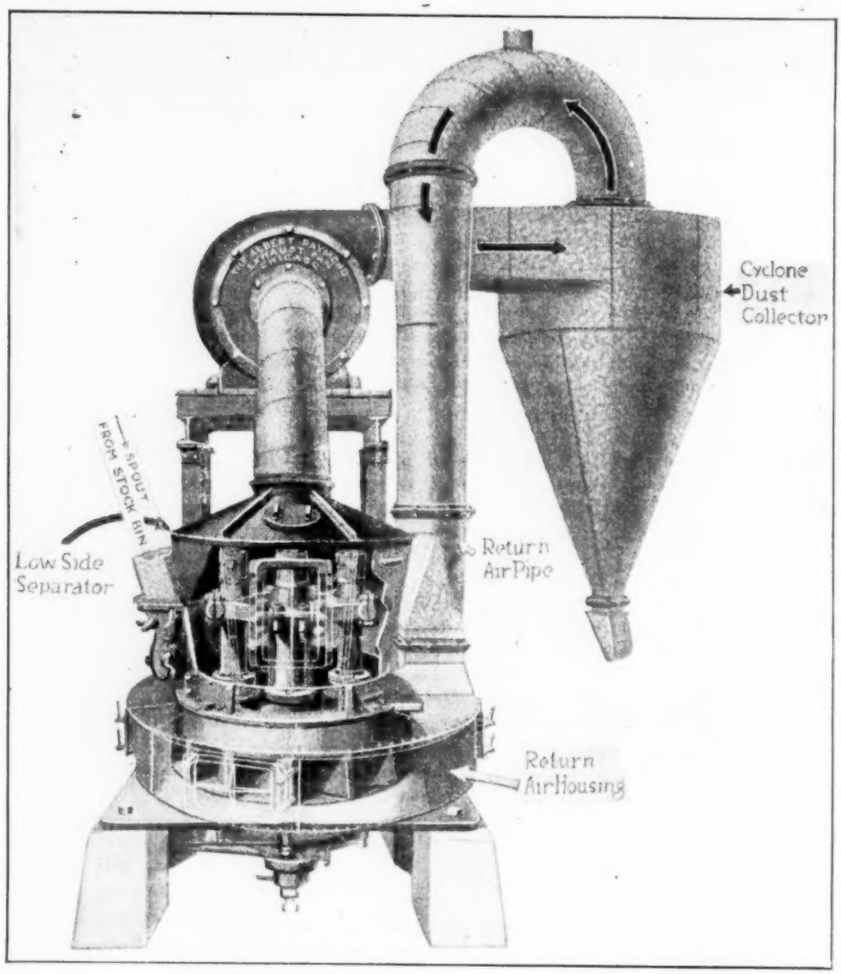

FIG. 3 RAYMOND SYSTEM OF AIR SEPARATION

to be reground, while the finer particles of which the centrifugal force is not great enough to overcome the fan suction, pass into the front intake.

The important feature of this type of separator is that the separation does not depend on the air velocity or air density. Because of this high air velocity can be employed.

Among the advantages of air separation is claimed the fact that a finer product can be obtained than by the use of the finest screens. The full import of this statement may be realized when we bear in mind that there are screens in the market of 350 meshes to the linear inch, or 122,500 holes per square inch. Air separation may also be usefully employed with materials which either are, or tend to become sticky, such as resin, pitch, shellac and various gums. (*Compressed Air Magazine*, vol. 25, no. 7, July 1920, pp. 9722-9723, 3 figs., *dc*)

INTERNAL-COMBUSTION ENGINEERING

Rotary Air-Cooled Engine with Variable Piston Stroke

ZEITLIN VARIABLE-STROKE AERO ENGINE. Description of a 220-hp. engine shown at the recent International Aero Exhibition, London.

The engine is of the rotary air-cooled type with nine cylinders and its particular interest lies in the fact that the piston stroke is varied through the cycle. This is accomplished (Fig. 6) by fitting an eccentric to the big end of each connecting rod and rotating the eccentrics around the crankpin at half the engine speed by means of gear-

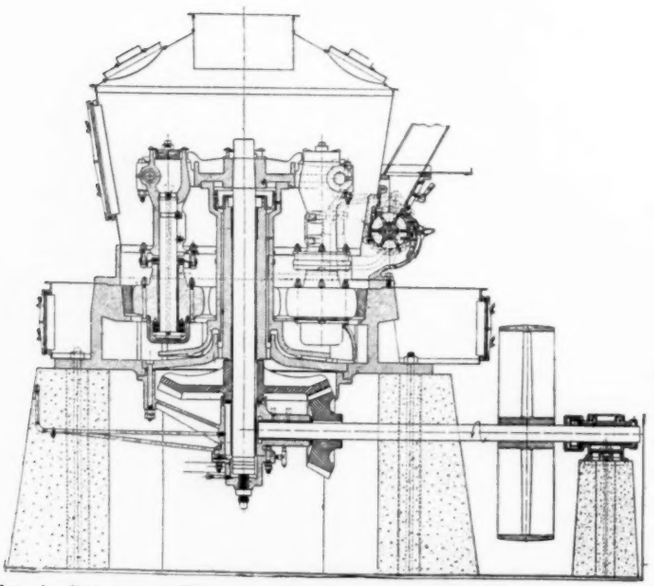

FIG. 4 SECTION OF MILL AND AIR-SEPARATOR CONNECTIONS IN THE RAYMOND SYSTEM OF AIR SEPARATION

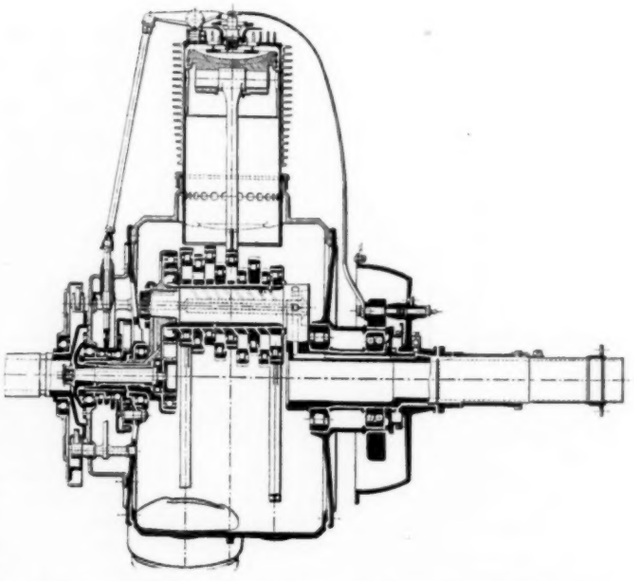

FIG. 5 ZEITLIN VARIABLE-STROKE AERO ENGINE, SHOWING DRIVE OF ECCENTRICS ON CRANKPIN

circular path due to the increased radius of the separator. Because of this the coarser particles are constantly being thrown against the sides of the separator and brought back to the mill

ing. The cycle of operation is as follows: On the working stroke each piston of the engine travels inward a distance of 181 mm. returning on the exhaust stroke for a distance of 203.5 mm. so

as to clear the cylinder of the gases of combustion more thoroughly. The exhaust valve remains open for the greater part of the suction stroke, but after it has closed the piston continues to

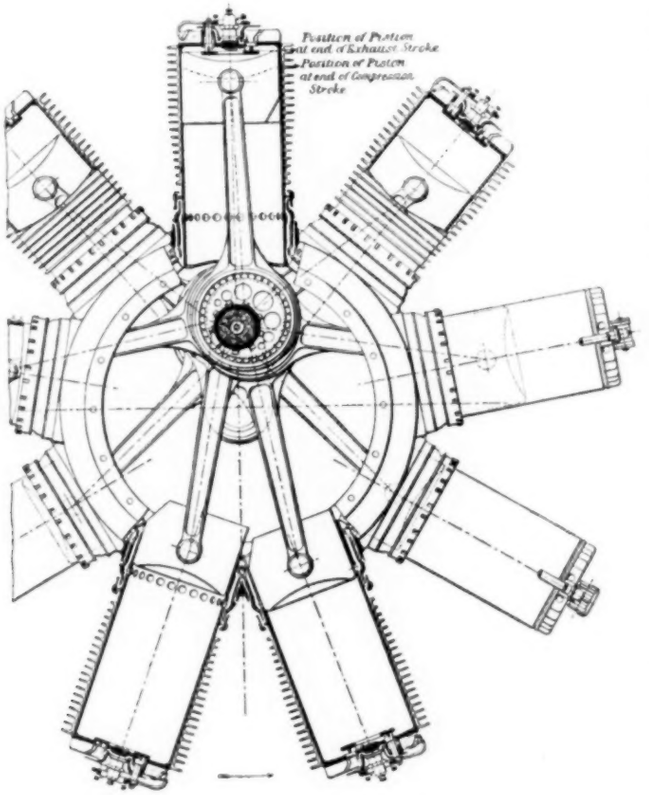

FIG. 6 ZEITLIN VARIABLE-STROKE AERO ENGINE, SHOWING TWO POSITIONS OF PISTON THROUGH THE CYCLE

move for a total distance of 226 mm., uncovering inlet ports in the cylinder liner near the end of the stroke. These inlet ports are connected with the crankcase and the partial vacuum in the cylinder is sufficient to draw in gas from the crankcase when the ports are uncovered. On the compression stroke the piston travels a distance of 203.5 mm.

The method of driving the eccentrics on the crankpin is of interest. To reduce the friction as much as possible, it is desirable to rotate the eccentrics in the same direction as the engine. One way to do this is to fit a small idler pinion between the fixed wheel on the engine center and the gear attached to the eccentrics. This, however, would involve certain difficulties and instead of the idler wheel a toothed ring encircling both gears is employed. This toothed ring (Fig. 5) is supported on large ball bearings. The exhaust valves, of which there are nine and which are of the annular type, are operated by three cams driven by epicyclic gearing.

In connection with the exhaust-valve mechanism, the engine is provided with a device to compensate for changes in altitude. The exhaust valve is normally kept open for a certain fraction of the suction stroke arranged, say, to allow the admission of a quantity of air calculated to give the correct compression at a height of 15,000 ft. The quantity admitted at lower altitudes with the same arrangement would, however, be excessive, but reduction of pressure is accomplished by opening the exhaust valve for a certain part of the compression stroke so that some of the air is expelled before it has had time to mix with the gas admitted through the ports.

The engine is said to develop 220 b.hp. and the weight per b. hp. is well below 2 lb. (*Engineering*, vol. 110, no. 2848, July 30, 1920, pp. 138-139, 3 figs., *d*)

Motor-Car Air-Cooled Engine with Burt Single-Sleeve Valves

AIR-COOLED SLEEVE-VALVE ENGINE. Description of a radial 3-cylinder motor-car air-cooled engine fitted with the Burt single-sleeve valve. The engine as shown in Fig. 7 has a bore and stroke of 80 by 90 mm. (3.14 in. by 3.54 in.), and its most interesting feature is the sleeve valve, a construction which presents unusual difficulties in an air-cooled engine because of the conditions for heat disposal which are present. In this case the sleeve is given a movement which is a compound of up and down and rotational movements, so that a point marked on the sleeve would in a complete cycle trace an ellipse.

The sleeve is operated by means of a small crankpin carrying a short horizontal connecting rod, the small end of which is attached to lugs at the bottom of the sleeve by means of a pin having a vertical axis, that is, an axis at right angles to the axis of the crankpin.

The place of the usual camshaft is taken by a small crankshaft driven at half engine speed with separate crankpins for each cylinder. There is a separate crank for each cylinder driven by means of skew gearing, the crown wheel of which is mounted at the side of the main crankshaft remote from the fan.

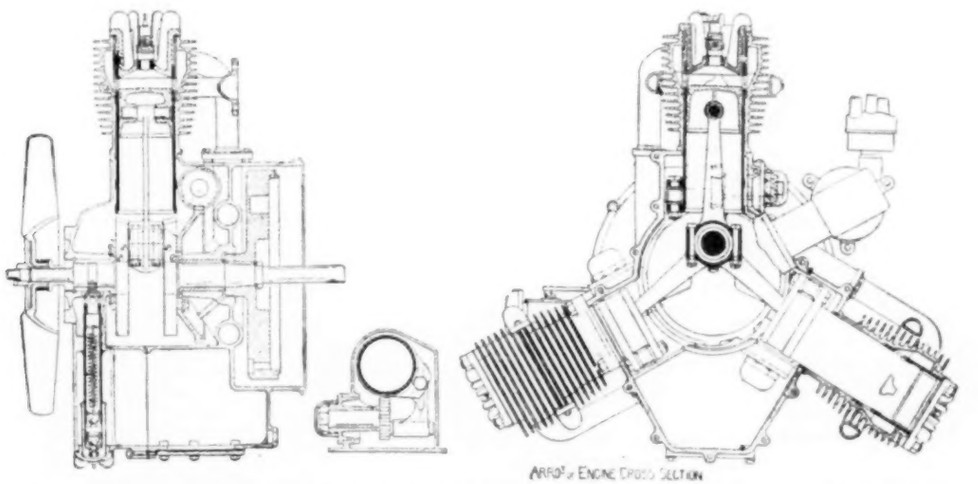

FIG. 7 RADIAL 3-CYLINDER MOTOR-CAR AIR-COOLED ENGINE WITH BURT SINGLE-SLEEVE VALVE

One of the features of the valve system, Fig. 8, is that inlet and exhaust ports are placed alternately round the cylinder, and the ports in the sleeve therefore act alternately for admission and exhaust, which helps to cool the sleeve. The cold incoming mixture circulates round an annular space at the top of the cylinder,

cooling the latter and also the cylinder head. (*The Autocar*, vol. 45, no. 1296, Aug. 21, 1920, pp. 317-318, 5 figs., *d*)

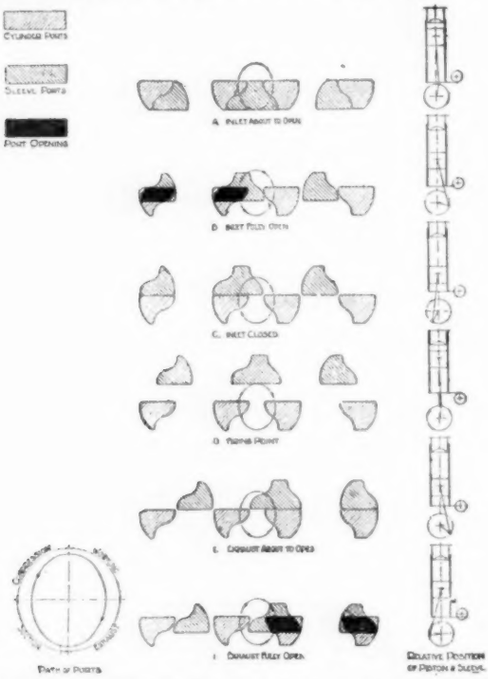

FIG. 8 DIAGRAM SHOWING RELATIVE POSITIONS OF THE INLET AND EXHAUST PORTS DURING A COMPLETE CYCLE IN ONE CYLINDER OF THE BURT SINGLE-SLEEVE-VALVE ENGINE

MACHINE SHOP

Seriatim Theory of High-Speed Punching Applied also to Perforation of Armor Plate by Projectiles

THE LAWS OF HIGH-SPEED PUNCHING, Capt. T. J. Tresidder. Paper issued by the War Office, Ordnance Committee Press, presenting a novel theory of punching which the author calls the Seriatim Theory of High-Speed Punching.

The theory is of importance also to artillerists as it enables them to determine the remaining velocity of a projectile perforating a given plate at a given striking velocity.

The method of procedure according to this theory is to separate the energy expended in perforating into its three components, namely, that expended on punching, that expended on overcoming friction, and that expended on giving velocity to the expelled plug, the laws governing the punching of a plate by a projectile being claimed to be exactly the same as those known to obtain in the case of plates punched in a punching machine.

The basic argument brought forward is to the effect that mean endlong pressure on the shell due to resistance to punching decreases as the velocity of the shell increases from the bare perforating velocity upward.

There is an important distinction between the blow the projectile can give and that which it does give. Up to bare perforating velocity it gives its all. Beyond the perforation point the blow given is only the maximum the plate can return, and the rest of its possible blow the shell carries on with it.

When a moving body—say, a shell—collides with a stationary one—say, a plate—the action and reaction between them, which are equal to each other, obviously cannot exceed the maximum of which the more feeble is capable. If the blow is arrested, the shot is the more feeble and the mean pressure will depend on its energy. If it is not arrested the plate is the more feeble and the mean pressure will depend on its resistance. If the latter decreases—according to the theory propounded—as speed of attack increases and makes the time available less sufficient for calling into action all the resources of the plate, pressure must decrease with it. Therefore, a shell which encounters a plate with only just enough velocity to perforate it will, according to this theory, be more stressed by, and will undergo more endlong presure from, the plate's resistance than if its velocity were twice as great.

Consider the force required to punch, as in a punching machine, four plates, each ¼ in. thick, arranged with three thinner hard plates, which have been already perforated, between them. The thin hard plates—that is, the second, fourth and sixth of the pile—will then act as holders-up for the first, third and fifth, the seventh being held up by the die of the machine as usual. Clearly the pressure that must now be applied to the punch to perforate the four ¼-in. plates—1 in. altogether—is theoretically only the same as would be needed for one ¼-in. plate. That is to say, if a punch can deal with a plate by punching one-fourth of its thickness at a time, it need only have behind it one-fourth the pressure otherwise necessary. Similarly, if a plate is made up of a thousand or ten thousand laminæ which can be separately punched seriatim, the theoretical force or pressure between punch and plate need only be one-thousandth or one ten-thousandth of that required for the solid plate. The distance separating the laminæ need only be sufficient to allow each to fail to shear before the next is seriously engaged, and as this distance will certainly be less as the speed of punching is greater—for the higher the speed the more thoroughly is each lamina held up by its own inertia—it is not inconceivable that as the velocity increases toward the infinite, there will be, in the case of a solid plate, a nearer and nearer approach to a sort of seriatim punching of hypothetical laminæ, whose number approaches infinity and whose thickness and distance apart approach zero.

This is followed by an interesting discussion of the classical case of a soft candle fired as a projectile through a wooden board.

The author's theory was checked by means of tests where measurement was made of the loss of energy suffered by certain projectiles in perforating certain plates at velocities far above those just necessary to carry a shell through. The bare perforating velocities were known. Knowing the energy lost by the projectile when it is just perforated and calling it A, and also knowing the energy lost by the same projectile in perforating the same plate at a higher velocity and calling it B, it was only necessary to compare A and B to test the truth of the main assertion of the Seriatim Theory, namely, that mean pressure due to resistance to punching is less as perforating velocity is greater, which proved to be true in every case.

The approximate net energy absorbed in overcoming the plate's resistance to punching at the high velocity—based on the observed remaining velocity—was compared with that at the low velocity. Their relation to each other was found every time to be, within reasonable limits of observational accuracy, inversely the same as the relation of the corresponding striking velocities.

This amounts to experimental proof of the statement that the net energy absorbed in the punching of a given plate by a given projectile, and also the mean pressure F on the projectile due to the plate's resistance to punching, varies inversely as the striking velocity.

It will be seen that, according to the Seriatim Theory, as V proceeds from perforation value to infinity, "pressure exerted," "work done", and "time taken" in overcoming the plate's resistance to punching, all diminish toward zero; but "power exerted", which is work divided by time, remains the same at all velocities, if time is fixed, since, however near to zero "work done" and "time taken" may be brought, their relation to each other remains unchanged, both varying inversely as the first power of the velocity.

Bearing in mind, then, that in the perforation of one body by another, energy is expended in three distinct ways, viz., punching, friction overcoming and plug propelling; and that of these we are at the moment dealing with only one, namely, punching, the following new dynamical law seems to result from the arguments of this section:

When any given body, in virtue of kinetic energy, passes completely through another given body without undergoing any change whatever of its own form or dimensions, the power it exerts in effecting the necessary rupture of the material of the perforated body is constant for all velocities.

The report covers many more features of apparently great importance which cannot be abstracted, partly because of lack of space and partly because of insufficient explicit data in the abstract from which this one is taken. (*The Engineer*, vol. 130, no. 3371, Aug. 6, 1920, pp. 126-127, *dtA*)

Comparison of British and American Practice in Hot Stamping

STEAM AND FRICTION STAMPS FOR HOT STAMPING, W. H. Snow. The author compares American and British practice in the matter of production of stampings and comes to the conclusion that American methods are far superior to the British. He explains this by the fact that the American stamper has had the advantage of a demand for quantities altogether beyond the orders usually met with in England and hence has been able to specialize to a high degree.

The author points out several constructional differences between American and British types.

American stamps, both board drop and steam, are self-contained, i.e., are built entirely on their anvil blocks. The British drop stamp follows ordinary steam-hammer construction in having the anvil block and the supports carrying the lifting gear independent of one another. The requisite alignment of the anvil block and tup is secured by resting guides in the block, the upper ends of the guides being supported laterally by the framework carrying the lifting gear, and being free to move vertically. In this way fewer parts of the stamp are affected by the shock of the blow, and a rigid foundation can be used, making for greater efficiency of blow. It is common to place the block directly on the concrete bed, though it is better to interpose a layer of timber of moderate thickness.

American stamps are generally bedded on timber to a depth of several feet—a rather costly arrangement—an elastic foundation being necessary to soften the shock of the blows on the stamp framework, etc., which carried on and bolted direct to the block would otherwise suffer unduly. In the case of steam stamps, the piston rod is a vulnerable part, and excessive ridigity in the foundation would result in a very short life. Experience has shown that nothing but the best materials are admissible in this type of stamp, if frequent and costly stoppages are to be avoided. In the best American practice, nickel-chrome steel, specially treated, is used for piston rods and heavy bolts, the tup is of specially selected steel, and the frames steel castings.

In British stamps the guides for the tup are generally straight bars of steel, or iron or steel castings of simple form carrying single or multiple "vees" engaged with the tup. The bars rest in holes in the anvil block, and are suitably held in the upper framework, as already mentioned. The lower ends of the bars are generally wedge-shaped, the holes in the block being formed to correspond so that the bars can accommodate themselves to some extent in the event of the block settling unequally and getting tilted. This is a bad arrangement, because the bars jump under the blows and then getting loose momentarily can twist, with the result that the tup is thrown out of alignment with the block.

In American stamps the standards, fitted with adjustable slides for guiding the tup, are made as supports of ample proportions for carrying the cylinder or the headgear, and are spread out at the base and accurately fitted to the block, which is a much better arrangement.

The universal practice as regards the upper die is to dovetail and key it into the tup. In American stamps the same plan is adopted for the lower die. A strong steel die holder of ample area is dovetailed into the block, and the die is held by dovetailing in the holder. There are no ready means of altering the position of the dies in relation to one another, and reliance is placed on accurate sinking of the impressions to secure the correct registering.

The general practice among British stampers is to have poppets fitted to the anvil block and to hold the die between screws—usually four in number—working in the poppets and pointing radially. (In France and Belgium six poppets with screws on rectangular axes are favored.)

There is also a material difference in the stamping processes used in the two countries. In American practice preparing for preliminary forming as well as the stamping of the article is done as far as possible under the same stamp. The original British method is to employ a dummying or preparing stamp alongside the main stamp and to rough out the article under it between suitable tools arranged with narrow and wide bases by the ordinary forging process. A variant on this plan is to use fast-running steam or power hammers for preparing quite independently of the stamping, the pieces being forged in numbers and then taken away to be reheated for stamping. This is a considerable improvement on the older method, as the saving in time by using high-speed hammers more than compensates for the cost of reheating and a much larger output per stamp is obtained.

An interesting feature of the British methods is disclosed by the author when he calls attention to the fact that the use of forging machines for upsetting is unknown in England.

The conclusion to which the author comes is that the British practice needs overhauling. He calls attention, however, to the fact that if American stamps were installed, but no change of methods of working adopted, the full advantage of their construction would not be realized. On the other hand, it would not be feasible to work on American lines with British stamps as their construction is much too weak for this. (*The Engineer*, vol. 130, no. 3373, Aug. 20, 1920, pp. 173-174, *cA*)

Practical Suggestions on the Use of Twist Drills

THE USE AND ABUSE OF TWIST DRILLS, H. Wills. Twist drills will stand more strain in proportion to their size than almost any other tool. The form of drill point is important because it controls the rate of production, accuracy of the hole, frequency of necessary grinding, and the life of the drill. Speed and feed are also of great importance.

When grinding the drill points the following rules should be observed:

Both cutting lips must be inclined at the same angle with the axis of the drill and must be of equal length. The point angle of 59 deg. has been universally adopted as best suited for average conditions.

The drill point must have the proper clearance or contour of surface back of the cutting edges and this clearance must be identical on both sides. Approximately a 12-deg. clearance angle combined with the center angle of 130 deg., which will give a constantly increasing clearance toward the center, has proven best for average conditions.

If the drill points are not properly ground a number of undesirable conditions will result.

An illustration in the original article shows how a gage can be used to determine approximately the center angle. Although the included angle of the gage is only 118 deg., a center angle of 130 deg. is recommended.

Twist drills are often made with a gradual increase in the thickness of the web about the shank, with the result that as the drill becomes short and the web thinner, greater force is required to drive it. To overcome this, it is good practice to thin the web by grinding away the excess thickness, reducing it to its original dimensions.

In grinding high-speed drills care should be taken not to overheat them, and when heated they should never be plunged into cold water.

As regards speeds and fits, tables are given in the original article for use on various commercial materials. If the drill is properly ground and the corners of the cutting lips begin to show rapid wear, it is an indication that the speed is too great. If the cutting edges roughen or break out in minute particles, it indicates that the feed is too great.

As regards very small drills, attention is called to the fact that they are very frequently run at an excessively low speed with the result that breakage is excessive. These are delicate tools. They must be run true and the cutting edges kept sharp. A fine-grade emery stone is best suited for this purpose. (*Iron Age*, vol. 106, no. 8, Aug. 19, 1920, pp. 461-463, 12 figs., *pA*)

MEASURING INSTRUMENTS

Electrical Apparatus for Registering Fuel Consumption on Motor Vehicles

THE BOWDEN PETROMETER. Description of a device acting electrically which registers the fuel consumption on a motor vehicle or aeroplane from moment to moment under all conditions.

As shown in Fig. 9, the petrometer consists essentially of a vessel divided more or less centrally by a diaphragm in which three passages are formed. One of these passages, on the left,

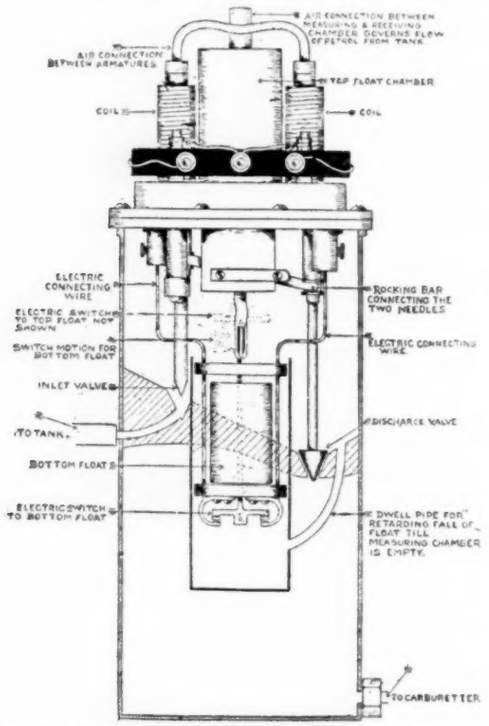
AIR CONNECTION BETWEEN MEASURING & RECEIVING CHAMBERS GOVERNS FLOW OF PETROL FROM TANK
AIR CONNECTION BETWEEN ARMATURES
TOP FLOAT CHAMBER
COIL
COIL
ELECTRIC CONNECTING WIRE
ROCKING BAR CONNECTING THE TWO NEEDLES
ELECTRIC SWITCH TO TOP FLOAT NOT SHOWN
ELECTRIC CONNECTING WIRE
SWITCH MOTION FOR BOTTOM FLOAT
INLET VALVE
DISCHARGE VALVE
TO TANK
BOTTOM FLOAT
ELECTRIC SWITCH TO BOTTOM FLOAT
DWELL PIPE FOR RETARDING FALL OF FLOAT TILL MEASURING CHAMBER IS EMPTY
TO CARBURETTER

FIG. 9 THE BOWDEN PETROMETER FOR MEASURING FUEL CONSUMPTION OF A MOTOR-VEHICLE ENGINE

is connected to the main supply pipe from the tank and can be closed by a needle valve; the second passage, connecting the upper and lower chambers, is opened and closed by another and larger valve. The third passage through the diaphragm, connected by a pipe to a central barrel, is set midway through the diaphragm and is equipped with two disks with a float chamber between them.

Beneath the lower disk are two curved contact pieces, wired through this disk and the upper one—and rigidly, for constructional support—up to the terminals of the coils, which are mounted on a platform above, and outside the fluid-containing vessel, along with an upper float chamber, the armatures—not shown—that carry the needle valves, and the positive terminals from the source of electricity. Each float is mounted in a central spindle that carries a tungsten-tipped contact bar which makes or breaks the electric circuit for the upper or lower "loop," so to say, thus established, as it makes or leaves contact with the stationary contact pieces, making—in the case of the lower float chamber—only while it is empty, but breaking the moment the float lifts, when the lower, or measuring, chamber is full. The upper contact bar, on the contrary, makes contact from the moment the petrol is free to enter the upper or receiving chamber, and lift the upper float, and does not break contact until the upper float chamber is empty. The two needle valves are interconnected by a centrally pivoted rocking bar, which carried a free arm extending downward at a right angle to it, to engage a loop from the spindle of the lower float. The function of this arm and loop, so far as can be seen, would simply steady the fall of the lower float.

All that is apparent from the diagram is that during the "make" of the lower float contact bar, the left-hand coil is energized to lift the inlet needle valve beneath it, which remains lifted until the upper float chamber is sufficiently full from the reception of the petrol for the upper float to lift its contact bar into "make" contact; which action is simultaneous with the "break" of the lower contact bar from the lift of the float in the lower chamber by the entry of a certain amount of petrol through the free connecting or dwell pipe meanwhile. Then at the break of the latter, simultaneously with the make of the former, the left-hand coil is deënergized to drop its needle valve, while the right-hand coil is energized to lift the discharge valve into the measuring chamber, which, as the diagram shows, is in free connection with the carburetor.

The discharge valve is mechanically connected with the dial so that the moment it closes it registers the amount it has admitted into the lower or measuring chamber. The dial has two sets of hands—one, non-adjustable, registering the gross fuel consumption; and the other with a trip hand adjustable for the run con-

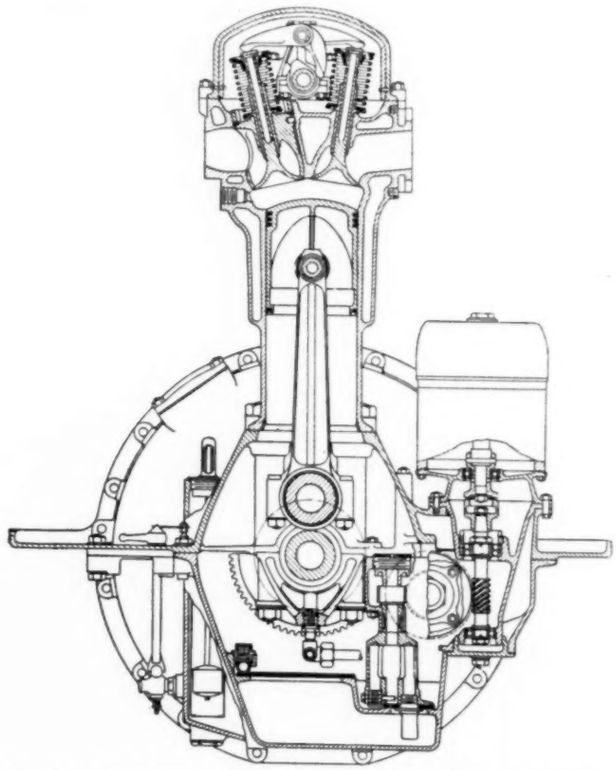

FIG. 10 CROSS-SECTION OF ENGINE ON NEW 40-HP. LANCHESTER CHASSIS

sumption. In the lower float chamber there is also installed a damping disk, which, acting like a paddle in the constant amount of fluid renders the apparatus proof against jerking or oscillations, which is an important feature. (*Auto-Motor Journal*, vol. 25, no. 31/1021, pp. 799-800, 4 figs., *d*)

METALLURGY (See Engineering Materials)

MOTOR-CAR ENGINEERING

Lanchester Motor-Car Engine

40-HORSEPOWER LANCHESTER CHASSIS. Description of the new Lanchester chassis of which the description of the engine is of particular interest.

The engine is 4-in. bore by 5-in. stroke and has a brake rating of 89 hp. at 2000 r. p. m. The cylinders are of cast iron and formed in two blocks of three cylinders. The inlet and exhaust ports in the integral cylinder head are so arranged that in each block two inlet and two exhaust valves have common ports, the

remaining two valves having separate ports. The two cylinders nearest the carburetor in each block have a common port and the areas and length of the ports and pipes are so arranged that each cylinder obtains an equal amount of mixture.

Two spark plugs per cylinder are fitted in a horizontal position immediately beneath the inlet ports. The spark points are in pockets communicating by small drilled holes with the combustion space which is completely machined, and the spark-plug bosses are completely surrounded by water pockets.

As regards the question of valve seats, the inlet valves only are fitted in a detachable cage, while the exhaust valves are seated directly in the cylinder head. The exhaust valve can, however, be readily removed by dropping it on to the piston head and withdrawing it through the inlet port. Each valve cage is pressed against a taper formed in the cylinder head and held in position by a circular nut slotted for a special wrench, a snug preventing the cage from rotating while the nut is turned.

tank the proper chemicals which either precipitate the scale-forming impurities or change them into impurities that are of non-encrusting character, or both; and also neutralize the free acid content of the water. In the settling tanks, of which there are two (used alternately) the treated water is first stirred and then allowed to stand for two to six hours, depending upon the load being carried.

The reagents used are lime to take care of the bicarbonates and free acid; soda ash for permanent hardness and soluble lime salts; and ferrous sulphate in sugar form to act as a coagulant and facilitate settlement.

Because of the fact that the impurities in the water vary quite irregularly frequent testing becomes necessary. Fig. 11 shows the variation produced in the water by the treatment described above.

The water flows by gravity from the settling tanks, in this case located on the roof of the building, to the filters, the flow being controlled by a float-operated valve so that the filter bed is always

TECHNICAL WATER ANALYSIS

ANA. NO. 7245 DATE 4-19-20

FOR A. M. Byers Company, Pgh. Pa.

SOURCE OF SUPPLY Monongahela River. WATER FROM Pittsburgh, Pa.

DETERMINED	GRAINS PER U. S. GALLON	PROBABLE COMBINATIONS	GRAINS PER U. S. GALLON
Volatile and Organic Matter	.65	Volatile and Organic Matter	.65
Silica	.85	Silica	.85
Iron and Alumina Oxides	.48	Iron and Alumina Oxides	trace
Calcium Oxide	2.24	Calcium Carbonate	
Magnesium Oxide	.96	" Sulphate	5.44
Sodium Oxide	.37	" Chloride	
Sulphuric Anhydride	5.00	" Nitrate	
Carbonic Anhydride (Fixed)	none	" Hydrate	
Carbonic Anhydride (Free)	.57	Magnesium Carbonate	
Chlorine	.50	" Sulphate	2.64
Nitric Anhydride	.11	" Chloride	.09
Nitrous Anhydride		" Nitrate	.12
Hydrate Water		" Hydrate	
		Sodium Carbonate	
		" Sulphate	
		" Chloride	.70
		" Nitrate	
		" Hydrate	
Acidity as H_2SO_4	.29	Ferrous Sulphate	.91
Alkalinity as $CaCO_3$			
PHYSICAL EXAMINATION		Total Solids	11.43
Turbidity (Silica Standard)		Suspended Matter	3.85 x
Color (Platinum Cobalt Std.)		Free Carbonic Acid	.87
		Sulphuric Acid	.29

Incrusting Solids 10.08 Grains per U. S. Gallon
Non-incrusting Solids .70 " " " "

REMARKS x Nature of suspended matter: mostly iron, silica and organic matter.

Respectfully submitted,
WM. B. SCAIFE & SONS CO.
A Per C.

TECHNICAL WATER ANALYSIS

ANA. NO. 7246 DATE 4-19-20

FOR A. M. Byers Company, Pgh. Pa.

SOURCE OF SUPPLY #7245 treated. WATER FROM Pittsburgh, Pa.

DETERMINED	GRAINS PER U. S. GALLON	PROBABLE COMBINATIONS	GRAINS PER U. S. GALLON
Volatile and Organic Matter	.25	Volatile and Organic Matter	.25
Silica	.45	Silica	.45
Iron and Alumina Oxides	trace	Iron and Alumina Oxides	trace
Calcium Oxide	.36	Calcium Carbonate	.65
Magnesium Oxide	.12	" Sulphate	
Sodium Oxide	7.61	" Chloride	
Sulphuric Anhydride	5.48	" Nitrate	
Carbonic Anhydride (Fixed)	1.14	" Hydrate	
Carbonic Anhydride (Free)	none	Magnesium Carbonate	
Chlorine	.67	" Sulphate	
Nitric Anhydride	.11	" Chloride	
Nitrous Anhydride		" Nitrate	
Hydrate Water	.32	" Hydrate	.17
		Sodium Carbonate	2.06
		" Sulphate	11.50
		" Chloride	1.11
		" Nitrate	.17
		" Hydrate	1.20
Acidity as H_2SO_4			
Alkalinity as $CaCO_3$	4.40		
PHYSICAL EXAMINATION		Total Solids	17.56
Turbidity (Silica Standard)		Suspended Matter	trace
Color (Platinum Cobalt Std.)		Free Carbonic Acid	none

Incrusting Solids 1.27 Grains per U. S. Gallon
Non-incrusting Solids 16.04 " " " "

REMARKS:

Respectfully submitted,
WM. B. SCAIFE & SONS CO.
B Per C.

FIG. 11 WATER ANALYSIS BEFORE AND AFTER TREATMENT AT BYERS PLANT

Both inlet and exhaust valves are made from tungsten steel. The cross-section of the engine indicating the general arrangement is shown in Fig. 10. (*The Automobile Engineer*, vol. 11, no. 141, Aug. 1920, pp. 311-318, 20 figs., *d*)

POWER-PLANT ENGINEERING

WATER-SOFTENING IN PITTSBURGH DISTRICT. The condition existing in the Pittsburgh district with respect to boiler feedwater is that the liquid available for this use in its natural condition is not water but a changing solution of several scale-forming substances with a liberal percentage of free acid and undissolved organic matter. Under these conditions boiler troubles would be inevitable unless some means were taken to control the chemical constitution of feedwater. The present article describes the experience of, and methods developed for such control of feedwater by the plant of the A. M. Byers Company and at the mine and coke plant of W. J. Rainey at Allison.

At the Byers plant the water is taken directly from the Monongahela River and used as condensing water in jet condensers, so that it is delivered to the hot well at a temperature of about 70 deg. From the hot-well part of the water is used in hydraulic presses, while the remainder goes to the softening system where it is treated for boiler use.

This water is treated in an intermittent system. The process in the main consists in adding to the water as it enters the settling

covered but the condensers never overflow. Another float-operated valve prevents flow from the filter to the clear-water tank when it has become filled.

When the plant began using treated water the boilers were heavily encrusted with hard scale. Because of this, only a partial treatment was used to prevent the scale from coming down too rapidly and causing burned tubes. This treatment was gradually increased until the heating surfaces were free from scale. Previous to the introduction of water treatment continual trouble was experienced necessitating replacement of drums and tubes. During the six months that the treating plant has been in operation the tube replacements have been reduced to almost nothing and shutdowns on account of bad water have been entirely eliminated. (*Power Plant Engineering*, vol. 24, no. 16, Aug. 15, 1920, pp. 777-784, 16 figs., *d*)

STAMPING (See Machine Shop)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

A $30,000 Contribution for Coöperative Research

A VERY striking example of how coöperative research may work out in practice is shown by the recent contribution of $30,000 made by the General Electric Company to extend the investigations of the Committee on Fatigue Phenomena of Metals of the Division of Engineering of the National Research Council into the field of nickel steel. This work was originally planned to cover carbon steels only, and was heretofore supported by Engineering Foundation, which appropriated $30,000 for two years' work, and by the University of Illinois, which contributes the equivalent of about $12,000 in the services of Professor Moore and in space, heat, light and equipment.

Although fatigue failure of metal parts subjected to rapidly alternating stresses has been recognized for many years, the recent era of high speeds has yielded cases of great number and importance—in connection with steam-turbine shafts and rotors, airplane-engine crankshafts, the hulls of steel ships, axles and shafts in railway cars, motor cars and trucks, and other machine parts. Such metal parts occasionally fail under ordinary service conditions without showing any general distortion or other symptoms, even when the material is known to be highly ductile. These failures are found only in parts subjected to alternations of stress repeated in some cases millions of times, and therefore are attributed to fatigue of the metal.

Recognizing the value of the results of these investigations to the industries of the country, Engineering Foundation Board about a year ago made a grant of $15,000 a year for a period of two years for the investigation of fatigue phenomena in carbon steels, under a Committee of the Division of Engineering of the National Research Council. Articles of agreement were drawn up between the National Research Council, Engineering Foundation and the University of Illinois whereby the experimental work was to be done at the University of Illinois under the direct supervision of Prof. H. F. Moore, Chairman of the Committee. In addition to the services of Professor Moore, the University furnishes the necessary space and facilities for conducting the work to the best advantage.

Prof. J. B. Kommers, of the University of Wisconsin, a specialist in this subject, has secured a two-year leave of absence and is devoting his full time to the work together with a staff of assistants. The apparatus is all installed and the work progressing according to schedule.

The General Electric Company has recently signed an agreement with Engineering Foundation, National Research Council and the University of Illinois, whereby it agrees to contribute the additional sum of $30,000 to extend the work to include 3 per cent and 3½ per cent nickel steel. This extension is to be considered part of the original program and no restriction is placed by the General Electric Company on the publication of the results.

Although the results of this work on nickel steels will be of immediate commercial value to the General Electric Company, they will also be of value to other manufacturers. The attitude of the company is therefore an unusually broad-minded one. On the other hand, great economies will result from the coöperation agreed to. This is easily appreciated when one considers that the facilities, the supervising experts, and much of the apparatus for conducting these tests are already available and that the consulting services of a group of the foremost experts in the country are furnished without cost, the chief additional cost being some additional apparatus and junior assistants.

Moreover, the coöperative method with its concentration of talent makes much more likely the discovery of the fundamental laws of fatigue, which will be vastly more valuable than the mere empirical information as to the fatigue limits of two varieties of steel.

Thus the broad-gage, far-sighted policy of the General Electric Company demonstrates the commercial feasibility of coöperative research in the fundamentals of engineering, and opens up a large field of usefulness to the National Research Council and Engineering Foundation. It is also an illustration of the large cumulative returns likely to accrue from a wisely placed investment such as that made by the Engineering Foundation Board, which gave the necessary initial impetus to this movement.

Fuel for Motor Transport

The Fuel Research Board of the Department of Scientific and Industrial Research has prepared an interim memorandum on fuel for motor transport. The memorandum deals chiefly with the possibility of substituting alcohol for petrol and consists of three sections: (*a*) Historical, (*b*) The Present Position of Power Alcohol and (*c*) Alternate Motor Fuels. Copies (at 3d) may be obtained through any bookseller in England or from H. M. Stationery Office, Imperial House, Kingsway, London, W. C. 2.

Research Laboratories in Industrial Establishments of the United States

The Bulletin of the National Research Council for March, 1920, is devoted to a description of the research laboratories in industrial establishments of the United States compiled by Alfred D. Flinn, assisted by A. J. Porskievies and Ruth Cobb. The list contains the names of over 300 industrial establishments with research laboratories and gives the work done by the laboratories, the research staff, the equipment and the principal product of the company. This Bulletin will be of value to those requiring research work. The Bulletin is published by the National Research Council of the National Academy of Sciences, Washington, D. C., with publication office at 1201 16th St.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulae or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Air A1-20 Operation of Blowers in Parallel. Tests were conducted using two motor-driven fans of the single-width, multivane type with double inlet and forward-tipped vanes. Characteristics were obtained for parallel operation at different speeds discharging air against the same head. Certain negative characteristics were determined. The relative advantages of flat and steep characteristic types of forced-draft blowers are discussed. Work was done at the Naval Experiment Station, Annapolis, Md. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Apparatus and Instruments A11-20 Gas Analysis. Indicators for carbon dioxide and oxygen in air and flue gas by L. H. Milligan, D. O. Crites and W. S. Wilson are discussed in Technical Paper 238 of the Bureau of Mines. This paper shows the form of apparatus developed by the Bureau of Mines for determining carbon dioxide in large and small quantities. The apparatus is not quite similar in form to other apparatus used for this purpose. Address F. G. Cottrell, Director, Bureau of Mines, Washington, D. C.

Cement and Other Building Materials A10-20 Aged Cements in Concrete Mixtures. Cement which had been in storage for a year and a half has been tested after lumps had been removed by sieving. Concrete made with the old cement after sieving was compared with that made with new cement and it was found that a 1:1¼:2½ mix of old cement gave concrete equal to that of a 1:2:4 mix with new cement. Similar tests were conducted at Vicksburg, Miss., by the U. S. Engineers' Office. These results show that a 1:2¼:4½ mix of aged cement is equal to a 1:3:6

mix of fresh cement. Reference is also made to *Cement and Other Building Materials A7-20*, found in the September number of MECHANICAL ENGINEERING. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Chemistry, Inorganic A1-20 Manufacture of Hydrogen. The U. S. Naval Engineering Experiment Station at Annapolis, Md., has reported on an investigation of the possibilities of manufacturing hydrogen gas from carbocoal and steam. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Electric Power A4-20 Brake and Stray-Power Methods of Testing Motors. The U. S. Naval Engineering Experiment Station at Annapolis, Md., has reported on a test of comparison of brake and stray-power methods of testing variable-speed motors. Certain losses are not included in stray-power measurement and these tests show that losses amounting to from 1½ to 3 per cent are not determined by the stray-power method. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Foods A1-20 Food Investigating Board of Great Britain. Special Report No. 1 on Design of Railway Wagons, price 4d. Report No. 2 on The Literature of Refrigeration, price 5d. Address H. M. Stationery Office, Imperial House, Kingsway, London, WC2.

Fuel Utilization and Appliances A1-20 Gas Appliances. The Bureau of Standards has made a report on the work of the year in cooperation with the Industrial Fuel Committee of the American Gas Association. The proper design of air shutter, gas orifice and burner throat has been worked out and apparatus has been perfected for measuring the air and gas. The results show that many appliances used at present are low in efficiency and great improvement can readily be made. Some equipment uses only 10 to 30 per cent of the heat of the gas and can be made to yield 30 to 50 per cent. Investigations show that burners can be designed to operate natural gas at low pressure for use in the winter season and that the installation of regulators to supply gas at a low and uniform pressure at all times would result in savings. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Glass and Ceramics A1-20 Transverse Strength of Fireclay Tile. Fireclay tile subject to temperature of 1350 deg. cent. has been tested to determine modulus of rupture and deformation. Many of these tile cannot support any appreciable load beyond their own weight at this temperature. If loads are to be carried the investigation points to the need of entirely different compositions and combinations of clay and grog. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Mining, General A3-20 Output from Coal Miner. Report 2145 by W. W. Adams shows that the output per miner in the U. S. is greater than that in other countries. The amount has increased from 3.37 tons per day in 1901 to 4.40 tons in 1918. New South Wales 4.07 tons per day in 1917, Nova Scotia 3.35 tons per day. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

Refrigeration A2-20 Food Investigating Board of Great Britain. Special Report No. 1 on Design of Railway Wagons, price 4d. Report No. 2 on the Literature of Refrigeration, price 5d. Address H. M. Stationery Office, Imperial House, Kingsway, London, WC2.

Sound A1-20 Submarine Sound Research Work. The U. S. Naval Engineering Experiment Station at Annapolis, Md., has completed for the navy sound research work of the following nature:

(*a*) Determination of relative efficiency of sound-signaling receiving devices with regard to sensitivity
(*b*) Determination of relative efficiency of four types of installation with regard to directivity
(*c*) Depth sounding with listening devices
(*d*) Comparison of German and United States oscillators
(*e*) Interfleet communication using listening devices and oscillator
(*f*) Investigation of screening effect of hull of vessel upon transmission and reception of sound waves
(*g*) Determination of relative sensitivity and directive qualities of MV electrical blister installation for submarines
(*h*) Skin installation of MV microphone receiving lines
(*i*) Investigation of sound apparatus for battleships
(*j*) Development of range finder
(*k*) Sound reception in deep water.

Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Steam Power A1-20 Flow of Steam. The U. S. Naval Engineering Experiment Station has reported a résumé on the flow of steam through pipes and fittings to the Bureau of Steam Engineering of the U. S. Navy. See August, 1920, number of *Journal A. S. N. E.*

Water, Sewage and Sanitation A3-20 Water Supply and Sewage Disposal for Country Houses. No. 21 of the Engineering Experiment Station Series of the University of Missouri is devoted to the water supply and sewage disposal for country homes by E. J. McCaustland, Director. This Bulletin of 36 pages gives construction, drawings and diagrams for the installation of systems of water supply and sewage disposal for country homes. Address E. J. McCaustland, Director, Engineering Experiment Station, Columbia, Mo.

B—RESEARCH IN PROGRESS

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Cement and Other Building Materials B3-20 Preserving Coatings for Stone. The Bureau of Standards is investigating a colorless surface treatment for stone for the prevention of disintegration by weathering. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Fuels, Gas, Tar and Coke B4-20 Oil Shales. An investigation of the fundamentals of oil-shale retorting is being carried out by the Bureau of Mines. A report No. 2141, by M. J. Gavin, has been made to the Bureau on the plan of this work. In June a report was made by the same author on oil shales and their economic importance. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

Glass and Ceramics B2-20 Glass Industry. The Bureau of Standards is endeavoring to develop an improved refractory for the construction of pots for glass making, with particular reference to corrosion. A systematic study is being made of bodies composed of silicious bond clays mixed with aluminous grog and aluminous bond with silicious grog. Crucibles of these mixtures will be fired and then subjected to the action of corrosive barium glass. On breaking the crucibles the depth of penetration will determine the value of the mixture. The transverse strength of the mixture in the dry and fired state, as well as its shrinkage, will be determined. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography B9-20 Bearing Alloys. The tests of babbitt bearing alloys at elevated temperatures have shown that the yield point and ultimate strength decrease rapidly with increasing temperatures. Babbitts containing lead lose their strength more rapidly than those with a tin base. Brinell hardness measurements are being made. Varying quantities of tin are being added to high-grade tin-base babbitt to study the physical properties. A thermostatically controlled air bath is being used for annealing specimens over long periods of time. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography B10-20 Microstructural Change on Tempering Steel. Elaborate series of examinations to determine changes in structure of hardened steels upon tempering has been started at the Bureau of Standards. Magnetic tests and density determinations have indicated pronounced changes. Six different types of steel are being used with carbon content varying from 0.07 per cent to more than 1 per cent. The steel will be hardened by quenching in water from various temperatures, and the length of time at which the material is held at the quenching heat will also be considered. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography B11-20 Materials Investigations. The U. S. Naval Engineering Experiment Station is at work on investigations of failures in shafting, boiler parts and condenser tubes and on new metals and alloys. The work is to determine cause of failure or to obtain data for the revision of specifications. The Bureau is also at work on investigations of impact, resistance and endurance properties of metals. It is also performing experimental work for the Joint Committee on Investigation of the Effect of Phosphorus and Sulphur in Steel. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

Steam Power B3-20 Boiler Water. The U. S. Naval Engineering Experiment Station is investigating the treatment of boiler water by the use of aluminous plates. Address Bureau of Steam Engineering, U. S. Navy, Washington, D. C.

C—RESEARCH PROBLEMS

The purpose of this section of Engineering Research is to bring together persons who desire coöperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring coöperation or aid will state problems for publication in this section.

Heat C1-20 Heat Transmission to Air at High Pressures. Experimental information regarding the coefficient of heat transfer through steel from gas to compressed air under pressures ranging from 300 to 3000 lb. per sq. in., with a temperature range from —10 deg. fahr. to 60 deg. fahr. is desired. Address W. S. Aldrich, American Bridge Company, Master Mechanics Department, Gary, Ind.

D—RESEARCH EQUIPMENT

The purpose of this section of Engineering Research is to give

in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

E—RESEARCH PERSONNEL

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

F—BIBLIOGRAPHIES

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. or to others recommended by members of the A.S.M.E. These bibliographies are on file in the offices of the Society.

Fuels, Gas, Tar and Coke F6-20 Coal Storage. Technical Paper 235 on Safe Storage of Coal, by H. H. Stock, gives instructions for storage and includes bibliography of technical papers on this subject published by the Bureau of Mines, the Engineering Experiment Station of the University of Illinois and articles published in technical journals. Bureau of Mines, Washington, D. C. Address F. G. Cottrell.

Machine Tools F1-20 Metal-Cutting Tools. A bibliography of five pages on metal-cutting tools from 1918 to June 1920. Search 3061. This supplements *Machine Tools F1-19* from 1903 to 1918. Search 2546. Address A.S.M.E., 29 West 39th St., New York.

Petroleum, Asphalt and Wood Products F5-20 Recent Articles on Petroleum, and Allied Substances. The Bureau of Mines receives monthly reports on the above subject by E. H. Burroughs, Editorial Assistant. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this Journal, brief articles of current interest to mechanical engineers, or suggestions from members of The American Society of Mechanical Engineers as to a better conduct of A. S. M. E. affairs.

Making the New Federation a Success

TO THE EDITOR:

A new machine has been designed, called a "Federation," to enable the engineering profession to act unitedly on matters of public welfare in which the profession as a whole is interested. In the September issue of MECHANICAL ENGINEERING Mr. Morris Llewellyn Cooke finds fault with the design of this machine, which he declares to be "short-sighted almost to the point of insuring failure." He gives as his reason that the Constitution of the new Federation permits the governing boards of the Societies to elect the representatives to the new American Engineering Council instead of having them elected by popular vote of the membership.

But is this distinction, after all, such a very important one? A great many good people labored long and diligently a few years ago to reform the United States Senate. They secured a Constitutional amendment requiring the Senators to be elected by popular vote instead of by the State Legislatures; but does Mr. Cooke think any large improvement has resulted in our Senate? Is it not a fact that representative government sometimes works better than purely democratic methods? What percentage of this Society's members would really take an active interest in the selection of the Society's representatives on the new American Engineering Council?

And whether Mr. Cooke and other critics of the Federation are right or wrong is not important now, *for the time to criticise has passed.* If the profession wants machinery by which it can speak with a united voice on public questions, then the only thing to do is to go in whole-heartedly and make the new Federation a going concern. If the machine proves defective here and there (and it probably will, for few new machines come from the designer perfect), then alter it as experience and wisdom accumulate.

Let us remember the great amount of energy and ability that has been devoted to planning this Federation. If the results of all this work are to be discarded by the profession, it is unthinkable that another set of men would begin over again the toilsome task of harmonizing differences of opinion and evolving a plan in which all existing societies of engineers could coöperate.

The only thing to do, then, for every engineer who believes in coöperative action by the whole profession, is to "boost" the Federation, and find how it may achieve the largest measure of success. Let us remember, too, that success is always a relative term. Many engineers will have "mighty purposes" in mind, such as Mr. Cooke alludes to, which the new organization will probably be unable to effect. The experience of the present Engineering Council has shown that there are very real limitations on the work *any* such body can do. There is, however, plenty of work within its powers awaiting the new Federation, and it can succeed if the profession will give it the necessary backing.

CHARLES WHITING BAKER.

30 Church Street,
New York, N. Y.

A Word of Caution Regarding the Federation

TO THE EDITOR:

To those of us who went through the harrowing days at the beginning of our participation in the war of 1917, there can be no doubt of the value of an organization harnessing together, for the national security, development and welfare, all those engineering activities which lie at the very foundation of our industrial strength in every line.

I believe I can give no clearer indication of the national need in emergency than to say that within one year after our entry into the war there had been coördinated under the direction of the Council of National Defense, with whose Advisory Commission I had the honor to serve as a member, more than 144,000 distinct organizations of various kinds throughout the United States.

One strong word of caution I should, however, like to voice. We should endeavor at every point to make The Federated American Engineering Societies a truly practical and workable agency for definite accomplishment. We should avoid the pyramiding of new engineering activities, committees, boards, etc., which are so apt to come into being for the furtherance of localized and sometimes selfish interests of individuals or societies and which tend to still further confuse a sufficiently complicated situation. The activities of many of our society members of The Federated American Engineering Societies already overlap, and as these societies endeavor to develop and extend their prerogatives we may naturally expect further complications in authority and in duplication of work.

We have in The Federated American Engineering Societies a coördinating influence which can be made of inestimable practical value, both to its member organizations and to the departments in Washington. Let us see to it, therefore, that this new coör-

dinating body is made to efficiently fulfill those objects for which it has been created.

HOWARD E. COFFIN.

Detroit, Mich.

Comments on the Proposed Code of Ethics

TO THE EDITOR:

The writer is of the opinion that any attempt at a Code of Ethics to be adopted by The American Society of Mechanical Engineers, or by the engineering profession in general, is of doubtful value. He feels, however, that if we are to take such a step, it is worth while to contribute any comment that may aid in putting this in the best shape possible. The form of the report lends itself to a classification under three items, and the writer suggests that the numbered paragraphs be rearranged in accordance with this classification.

The engineer's relation to his own self-respect and to contact with the general public is considered in Pars. 1, 2, 3, 4, 9, and 11, and partly in Par. 12. The engineer's relation to his client or employer is considered in Pars. 5, 6, 7, and 10.

The engineer's relation to his fellow-engineers is considered in Pars. 8, part of 12, 13, and 14. The first three of these have to do with competition for employment.

In his relations to his own self-respect and to the general public, the first four paragraphs are noble and beautiful principles in which we all believe. They are, however, statements of such general character that it would be practically impossible to take any steps for discipline or enforcement regarding them unless the acts involved were so far contrary to all standards that the offender would be expelled from the Society whether there were any formal code of ethics or not.

The subject of reports and expert testimony—Par. 9—is undoubtedly a thing which we will all approve as stated. The writer would wish to state this even more forcibly; that is, that all reports and expert testimony should be given from a judicial standpoint, seeking the truth by including all facts and sound engineering principles. There should be no partisan bias leading to the omission of facts or the distortion of principles in order to reach the desired conclusion. The writer is very doubtful whether it is at all possible to enforce any such ethical principle by action of the Society's authorities on professional conduct.

The writer concurs in the statement in Par. 11 that we should avoid sensational, exaggerated or unwarranted statements about engineering work; but he takes exception to the second sentence of the paragraph to the effect that first descriptions of new inventions, processes, etc., for publication should be furnished only to the technical societies or to the technical press. He would prefer to see it stated that first descriptions, etc., should *preferably* be furnished to the engineering societies or to the technical press. He does not believe that this paragraph should prohibit the first appearance of any proper description in the general press when the engineer concerned finds that advisable.

The writer would prefer to see Par. 12 divided; one paragraph being that, "He should not advertise in an undignified, sensational, or misleading manner." The remainder of the present Par. 12 will be discussed in the comments referring to the engineer's relations with his fellow-engineers.

The statements of the engineer's relations with his clients or employers in Pars. 5, 6, 7, and 10 are all approved. These all register with one ethical principle: namely, that the engineer is not justified in any surreptitious action affecting the relation between himself and his client or employer which would not be approved by them if they were aware of such action.

The engineer's relations with his fellow-engineers when competing with them for business or employment, Par. 8, and parts of Pars. 12 and 13, are more open to question. These set up standards which, if conformed to by the more careful, conscientious members of the profession, would place them at a disadvantage with a considerable percentage of the profession who are not so scrupulous. As stated, they would be very difficult of enforcement. There is at the present time an effort to establish minimum rates for certain classified positions. It would be entirely proper to forbid engineers from seeking such positions at less than the minimum rates in cases where such have been established. We will all agree that no engineer should improperly solicit professional work, but there is likely to be a wide diversity of opinion as to what is and what is not improper.

Everybody will approve Par. 14, regarding engineers assisting each other by exchange of information and experience. This, of course, is ideal. I believe we already approximate to this to a considerable degree. It is not, however, a principle which any authority could be expected to enforce against any individual who was unwilling to conform.

C. M. SPALDING.

Erie, Pa.

TO THE EDITOR:

The Code of Ethics published in your September issue of MECHANICAL ENGINEERING is short, general in scope and positive. Furthermore, it has "teeth," for the Committee of Professional Conduct will have very wide powers. The Code of Ethics Committee's report, therefore, meets the recommendation of the Committee on Aims and Organization:

> That it is the sense of this Committee that a short Code of Ethics of broad scope, general in character, and positive rather than negative injunction be prepared and that the same be vigorously enforced.

Some have asked the Committee for more detailed clauses. A book could easily be filled if any attempt were made to be specific in every case. The Committee has therefore felt that the Code should be confined to a few broad, underlying statements, leaving matters of interpretation and elaboration to the "Committee on Professional Practice," whose findings will receive full publicity in our publications.

Others have asked why a Code is necessary. They say that the Committee's recommendations state only principles that engineers have recognized as just and honorable even from school days. All of which is quite true of practically our whole membership, and yet cases have already been presented informally to your Committee for consideration where engineers of high standing have been in doubt over certain conditions that confronted them in practice. The Code will be particularly helpful to our younger members, who are often more in need of such guidance. In fact, every new member entering the Society should be furnished with a copy of the Code. The Committee on Professional Practice will also act in an advisory capacity to those in doubt on the ethics of certain proceedings.

Still other members have intimated that it is proposed to enforce laws and police duties on our Society. In the Committee's mind these are merely incidents connected with the larger problem, viz., the elevation of engineering to its proper place as one of the most honorable and most respected professions. How can this be attained? We believe that the only sure method is to set up high standards of conduct that will win the respect and confidence of the general public as well as of our own associates and as a Society to see that these standards are rightly upheld. When these conditions prevail, membership in our Society will be an honorable distinction.

Our members will enjoy a well-earned confidence and as men of justice will be sought after for public service which will enable them to render best service as citizens.

But your Committee does not want this code confined only to the mechanical engineers. We hope to establish a joint code and practice in which electrical, civil, mining and chemical engineers can coöperate to the one end, that of adding an honorable distinction and true professional character to engineering.

The Committee proposes to render a final report at the Annual Meeting in December which will contain a few minor changes from the preliminary code. In the meantime, the Committee urges the careful consideration of our first report by every member and will welcome the widest discussion of this most important subject.

A. G. CHRISTIE,
Chairman Code of Ethics Committee.

Baltimore, Md.

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Extending Ocean Navigation to the Great Lakes

CHARLES WHITING BAKER

TO make the St. Lawrence River navigable so that ocean vessels may reach the Great Lakes, and to develop the water power of the St. Lawrence Rapids, as described by Mr. H. C. Gardner in the last issue of MECHANICAL ENGINEERING, is without doubt by far the most important engineering enterprise now proposed in the world. Indeed, one may well go further and say that this enterprise promises to yield a larger public benefit in proportion to its cost than any engineering work of the first magnitude ever undertaken.

This statement may be criticised on the ground that only very general estimates of the work are as yet available. Enough is known, however, to fully warrant the above claim.

Perhaps a statement of some of the arguments for the St. Lawrence project, in addition to those made by Mr. Gardner, may make still clearer its value and importance.

The economies of transportation have been revolutionized in the past half century, in that *terminal expenses*, and not the cost of hauling between terminals, have become the controlling factor. This is well illustrated, indeed, by some of the figures quoted by Mr. Gardner; but it is a fact which few, even among engineers, thoroughly comprehend.

The great advanage of the St. Lawrence Route is that it would eliminate entirely the enormous terminal expenses in the congested terminals on the Atlantic Seaboard. On traffic moved between the Lake cities and foreign ports, a cargo of dressed beef at Chicago, or steel plates at Cleveland, or wheat at Duluth or Fort William, could be loaded directly on an ocean steamer, whose holds need not be opened until the steamer docked at Liverpool or other foreign port. Contrast this with the present cost of transfer between railway car and steamer at an Atlantic port, and the great saving by the St. Lawrence Route begins to be evident.

Another matter not mentioned by Mr. Gardner is that the great fleet of Lake vessels, which are now kept idle by the winter ice blockade for nearly half the year, could go down to the sea every fall and take part in the world's carrying trade during the winter months. Of course, a compromise type of vessel, fitted to navigate both the Lakes and the Ocean, would have to be evolved; but that would come about naturally. The United States is destined to become the great coal supply depot of the world. Vessels adapted to the Lake Superior ore trade could also handle to advantage coal to South America and Europe during the winter months.

But it may be asked, if the St. Lawrence project offers the greatest opportunity for profit in the world, why has it not long ago been undertaken? There are many reasons, but the controlling one is this: the profits from the creation of the St. Lawrence Route will go to the public. It is not an enterprise that can possibly be undertaken by private capital to make money. Had this been possible, it would long ago have been completed. Where public welfare is concerned, however, one finds few willing to give the time and energy required to carry an enterprise from the stage of a mere project to practical success.

Further than this, in order to carry out the St. Lawrence project, at least four Governmental bodies must grant consent or take an active part, viz.: the Governments of the United States and of the State of New York, and those of the Dominion of Canada and the Province of Ontario. The various private interests which have reason to oppose the St. Lawrence Route have found it easy, through one or the other of these Governmenal organizations, to hinder united action.

The reason why the St. Lawrence project has at last reached a stage where there is promise that it may become a reality, is because an organization has been effected under which fourteen States of the Northwest have united in a league to promote this project, and are doing it officially through their State Governments.

If this organization continues and the work of promotion, public education, and planning the details of the enterprise is carried on with the same energy and ability that would be the case if the project were being furthered as a private enterprise by a powerful financial syndicate, then the success of the project appears certain.

CHARLES WHITING BAKER.

A Great Work Possible in Industrial Education

As recorded in Section Two of this number, a meeting was recently held of the Committee on Education and Training of The American Society of Mechanical Engineers, at which there was a discussion of more than ordinary importance by a number of eminent authorities who are well-informed on the agencies now existing in the United States for all kinds of industrial training.

This movement for industrial training has taken on a surprising and broad development within recent years and many of the larger corporations already have schools for their men. The Federal Government, the separate states and private firms have made efforts to solve the problem of production by the better training of men to enter the fields of industry and transportation. The Vocational Board in Washington and the National Metal Trades Association have been working systematically towards this end.

At the committee meeting a statement was made of the methods followed by different types of schools, after which the question was raised as to the duty and opportunity of The American Society of Mechanical Engineers in this direction. Its members are well equipped by training and experience to lend a hand. Many of them are already doing this. The constitution of the Society defines its object as the "promotion of the arts and sciences connected with engineering and mechanical construction." It is clear from this that the Society would be entirely within its intended scope and would be building on a firm foundation by

taking an active part in the subject of industrial education, which is of such importance to the country.

It is obvious that the Society cannot undertake the instruction of young men for the profession and for the industries, but it *can* assist all the agencies of the United States toward a better understanding of the entire subject and toward greater coöperation. The smaller industries are in real need of information about the training of their men. If the Society should do nothing else than get out a report informing its members of the practice in different types of schools, including those within corporations, it would be contributing a useful work.

It is a year of opportunity in this country and The American Society of Mechanical Engineers ought to assist with all its might toward safeguarding against a lapse into the kind of barbarism masquerading under the name of Bolshevism. We do not belong to a profession confined solely to the technicalities of engineering, for the world has changed and we are part of the vast industrial system in which we must take our part. Hence a committee that will enable the Council of the Society to decide wisely upon the best method of serving the educational interests of the people can do as much for the future of engineering as the Boiler Code Committee is now doing, and that is a great deal.

IRA N. HOLLIS.

John R. Freeman Addresses Civil Engineers on Engineering Conditions in Japan and China

On the evening of September 15 Past-President John R. Freeman gave an illustrated talk before the members of the American Society of Civil Engineers and invited guests. The subject of Mr. Freeman's talk was Recent Engineering Developments in the Far East as noted during his eight months' sojourn in the Orient. The opening slides were devoted to manufacturing conditions in Japan, and included several pictures of modern factories engaged in the manufacture of electric lamps where the operators, under clean, light, healthy surroundings, worked at the very low wage of from 12 to 20 cents a day. Mr. Freeman felt that his welcome in Japan was sincere and that Americans, generally, were made to feel very much at home there.

Pictures relating to his visit to China covered the hydraulic bore at Hangchow, where a wall of water 15 ft. in height rushes up the bay at the equinoctial tidal season. Mr. Freeman also showed extensive views of the canal system of China, upon which the Chinese delta is dependent almost entirely for its transportation of food and cotton. The canals of China are examples of great engineering skill on the part of the Chinese, some of the masonry walls and locks having been built over 700 years ago and subject to frosts and torrents of destructive power. The bridges over the canals were constructed with great skill and true artistic appreciation.

Mr. Freeman is preparing a report on the proper procedure for removing the possibility of overflow of the Yellow River, which has caused immense loss of life during its flood periods by destroying the transportation system with consequent starvation. He made an extended trip through the Yellow River basin and had surveys of the country and studies of the old records of rainfall and flood channels placed at his disposal in this work. An interesting fact is shown in that the present channel of the Yellow River is located on a ridge, so that the upper normal level of the water is about 15 ft. above that of the surrounding country. The water is held in its course by dikes four or five miles apart, but which are incorrectly placed. These dikes require constant attention, and the Chinese local governments must be ready at all times to make the needed repairs. The water contains about 10 per cent silt by weight, which fills the bed rapidly and makes frequent cleanings necessary. This work is done by coolies, who remove the sediment into baskets at a cost of not more than 10 cents per cubic yard. Great mountains of silt were shown along the channel of the Yellow River. An interesting phenomenon of this river is its tendency to dig a deeper channel at high flood. Mr. Freeman is of the opinion that this tendency may be utilized in safeguarding the country against further floods.

Development of the Labor Situation in Australia

In general, it may be said that in no country in the world is the welfare of the worker hedged about by more legal safeguards than in Australia. In several states of the Commonwealth of Australia liberal provision is made for workers killed or injured in industrial disputes, old age and invalid pensions are paid, and minimum wages based on statistically-arrived-at cost of living are decreed by courts and boards for the settlement of industrial disputes and strikes.

In the July issue of the *Monthly Labor Review*, published by the Bureau of Labor Statistics in the U. S. Department of Labor, a summary of a report prepared by Trade Commissioner A. W. Ferrin of Melbourne, Australia, is included. This summary explains the development and growth of trade unions in Australia, starting with the increase of population in the cities caused by the influx of immigrants upon the discovery of gold in 1851. The building trade and printing trade unions were those first formed and were followed shortly by the stone masons. Unionism made rapid progress until, in 1919, the membership in trade unions was estimated at 580,000.

Two systems, based upon different principles, are in operation in Australia for the regulation of wages, hours, and general conditions of labor. The "wages board" system, prevailing in Victoria and Tasmania, has as its chief aim the prevention of disputes by the regulation of wages, hours, etc., by a special board appointed for a specific industry on application; while under the "industrial arbitration court" system, prevailing in Western Australia, an industry does not ordinarily come under review until after a dispute has actually arisen. New South Wales, Queensland, and South Australia have both systems.

The "wages board" system calls for the appointment by the Minister of Labor of a special board for a certain industry upon the request of employees or employers in that industry. An order is then issued, constituting a board of not less than four or more than ten selected by the Minister from nominations in the daily press. The constituted board elects a chairman, who votes only in case of a tie. The decisions of the board are submitted to the Minister for approval, and the employers and employees may appeal from the board's decision to a court composed of a judge of the supreme court of the State, appointed for a fixed period, and one representative each of the employers and employees, appointed for the duration of the case in review. The decision of this court is final.

Since under the industrial arbitration court system industries do not come under review until a dispute has arisen, it is quite feasible for the two systems to work together as they do in New South Wales, Queensland, and South Australia. Where wages boards are unable to settle satisfactorily the conditions in a given industry, either side can appeal to the industrial arbitration court and all agreements which have been reached by conferences between employers and employees can be registered with the court, thus acquiring the standing of court awards.

In spite of penalties against breaches of award, striking and locking out, strikes are very numerous. From 1913 through 1918 there have been 2152 disputes affecting 7697 plants, causing a loss of 8,756,389 working days, with a loss of £5,073,346. In 1919 the seamen's strike, causing an estimated loss of wages of £3,000,000, tied up industries in Victoria dependent upon coal from New South Wales. The marine engineers' strike, lasting for three months, ending Feb. 25, 1920, threw 15,000 persons out of work with a wage loss of £1,000,000. A strike of miners at Broken Hill, beginning in May 1919, is still in force. This strike is interesting in the manner in which it has been financed. Strikers understanding various trades, such as cobbling or barbering, contribute their services, the supplies being furnished out of a general fund which is made up of contributions from unions and individuals.

Another feature of Australia's labor disputes is the "go-slow" policy, or "lazy strike," which reduces output to a minimum, with the idea of forcing concessions from capital. It has been adopted with much effect in the Government dockyards,

where the riveters reduced their average of rivets to 73 per day per man against a normal of 273, and by telephone operators, who refused to answer more than a given number of calls per day.

In general, it may be said that neither capital nor labor finds the existing legislation for the avoidance and settlement of industrial disputes in Australia satisfactory. Labor is dissatisfied with the wage-board system because it fixes wages for a period, before the completion of which the rapid advance in the cost of living has made the award inadequate; and with arbitration because it believes that more can be obtained by direct action than by resorting to courts. Capital objects to both systems because of the difficulty of inducing labor to abide by awards and the belief that the boards and courts are too radical.

Commercial interests in Australia have expressed the desire that a new system be established whereby the employers and employees can meet on friendly terms and come to a proper understanding of each other's difficulties. In line with this idea, a royal commission has been appointed, sitting at Melbourne, to consider the subject of industrial unrest and to fix, if possible, a basic wage for the whole Commonwealth.

James Hartness To Be the Next Governor of Vermont

James Hartness, Past-President, The American Society of Mechanical Engineers, who has been a candidate for the Republican nomination for Governor of Vermont, won a sweeping victory at the primaries held on September 14. Mr. Hartness was one of four contestants for the nomination, and won by a vote of nearly two to one over his nearest competitor. Nomination is

James Hartness, Nominee for Governor

tantamount to election, and he may be safely greeted as "the next Governor of Vermont."

The Burlington (Vt.) *Daily Free Press* considers that the result marked "the triumph of the gospel of hope and progress for Vermont," and in commenting on the result says:

> The Hon. James Hartness of Springfield not only won the Republican nomination for Governorship, but he also gained a vote which at the hour of writing seems to have approached proportions of an actual landslide. . . . The people have been educated in this campaign to expect a genuine move toward a greater Vermont. We believe they will not be disappointed. Mr. Hartness will do his part. The only question now is whether we—the people of Vermont—will do our part to match his initiative and energy by helping to carry out his program for new opportunities for Vermont's youths.

The significant thing in Mr. Hartness' nomination is that it was accomplished by an engineer who used an engineer's methods, and that these methods won out before a jury of an American public. His success should have a potent influence in shaping public opinion in favor of such methods, and should be an inspiration to other engineers who are in a position to render effective service to the state or nation.

To understand the significance of the event, one must trace the history of the industries of Springfield, Vt., Mr. Hartness' home town. Those familiar with the machine-tool industry are acquainted with the remarkable industrial center which has developed in this community, comprising a number of prosperous firms which have sprung from the parent company, the Jones and Lamson Machine Company, which was established there through Mr. Hartness' efforts about 30 years ago. The spirit of the community has been to assist young men of inventive and administrative talent who have originated new tools and devices to establish organizations of their own under the direction of those who by training and experience are competent to conduct them.

As a result, Springfield has grown and prospered in marked contrast in this respect to most other towns of the state of corresponding size. The population of Vermont as a whole does not vary much from year to year. The larger towns and cities increase somewhat in size, but the smaller communities have a tendency to decrease. It is evident, therefore, that the fundamental problem in Vermont relates to those things which concern the organic life and growth of the state. It is evident that it is related only to a very slight degree to programs such as are usually propounded by legislators and politicians.

With characteristic originality, Mr. Hartness made a survey of the conditions of the state, and judged that something must be done to increase its industrial life which, in turn, would provide a better market for the produce of its farms and make the state an attractive abode for its young men. The broad-gaged policy which had been followed at Springfield had proved effective. Why should it not apply equally well elsewhere?

It was on this proposition that Mr. Hartness conducted his campaign, and in his first appeal to the public made the following statement:

> We can accomplish much by refining our business methods and in watching expenditures, but that will not make a material change in the conditions that confront us.
>
> I believe that the same spirit and energy that has been successfully displayed by Vermonters in agriculture, dairying, and various other state successes, can be displayed in other desirable industries providing we conduct a drive for industrial plant culture to awaken interest and activity.
>
> It is now proposed to inject this scheme of industrial plant culture into this campaign because it is the only way, it is the best way, it is the big way to solve our problems.
>
> One example of its working is found in the machine-tool industries that have grown from a single plant that brought $30,000 per year into the state in '89 to six plants that brought about $10,000,000 last year. The six plants are all prosperous and filled with young, enthusiastic people who are competent to start other plants. Nearly all of this sum comes into Vermont and is invested here.

As to the efficiency of legislation or administrative action in carrying out such a program, a recent bulletin issued in interest of the movement states: "A popular movement for carrying forward a state's interest in these matters constitutes a real big thing to be done at the present time. We can ignore the trend of this age of mechanism and machinery, or we can wake up to the importance of the plan of industrial plant culture. While we know that legislation cannot produce the skill of the worker or an artist, or the initiative of the industrialist, or the fruit of invention; the people can by popular opinion, expressed by the press and through their representatives in legislature, give encouragement or they can stifle and kill such development."

Noteworthy Papers on Labor, Management and Production

As repeatedly shown at the meetings of The American Society of Mechanical Engineers, both general and local, there is no single subject in which engineers are so vitally interested at the present time as that of labor and management. Of unusual interest to engineers, therefore, should be the September issue of *The Annals*, the bi-monthly publication of the American

Academy of Political and Social Science.[1] This contains a collection of 30 articles under the general title of Labor, Management and Production, divided under the four following headings: Part I, The Human Factor as the Heart of Industry; Part II, The Drift Toward Science in Industry; Part III, Some Major Problems of Industry; Part IV, The Manager's Part in the Adventure of Industry.

The series of papers was edited by Morris Llewellyn Cooke, Mem.Am.Soc.M.E., who has written the editor's preface outlining its scope and intent. Collaborating with him as editors were Samuel Gompers, President of the American Federation of Labor, representing organized labor; and Major Fred J. Miller, President, Am.Soc.M.E., representing the managers of labor.

In the selection of contributors, an effort was made to secure papers from two groups of authors of which the names of Mr. Gompers and Major Miller are representative; or, as expressed by the Academy when this issue of *The Annals* was planned, by the "organized workers" on one hand, and "scientists of industry" on the other hand. In selecting the latter, however, the editor states that "no one was asked to contribute to these pages simply because he owned something or employed somebody. Official standing in the labor movement and recognized service in the application of science to the purposes of industry have determined eligibility in every case." The contributors are from the United States, England and France, and it is pleasing to note that one of the French representatives in the list is Charles de Freminville, recently elected Honorary Member, Am.Soc.M.E.

The value to the engineer of such a selection of articles as comprised in this number of *The Annals*, as a source of information upon the problems of the labor movement, is well expressed by Major Miller in his foreword, who says:

"There can be no doubt that much of the misunderstanding between employer and employee may be traced to the fact that each reads, more or less exclusively, the publications that support his views—that indeed must do so, for reasons that are easily understood. Thus each side fails to get the other's viewpoint and it is certain that the industrial situation would be much improved if there could be more of that 'getting together' which accompanies a free interchange of views, to the end that each side may at least comprehend what the other stands for; and why."

Mr. Gompers, whose foreword is entitled The Workers and Production, recognizes in his opening paragraph that "production is the great world problem of today" and other of the labor representatives also take the stand for increased production as in the interest of the wage earner. Mr. Gompers says, however, that "The Workers and Production—the title under which I express these thoughts—means the workers and life. That is to say, the workers and the life of the nation, spiritual and mental as well as physical. To contribute to the thought that is centered upon a better life for those who work, upon a nobler life for the nation and a higher plane for it and the civilization of the world, is a privilege to be sought. The last drag upon the worker's heart and brain, upon his enthusiasm for service, upon his simple efficiency at the bench and forge, is the lingering ideal of production for profit alone. The greatest single achievement for progress possible to this day and this generation is the substitution in industry of the ideal of production for use—for service—and not for profit alone."

Major Miller, writing from the standpoint of industrial management, says:

> There are those who, for ten years or more, have recognized and have declared their conviction that the industrial world has been passing through a revolution—for the most part peaceful and constructive, but, nevertheless essentially, a revolution. The Hohenzollern war did not cause this revolution, but only accelerated what was already under way. Among other things it has shown us clearly that the old driver method of industrial management will no longer do. The workmen of the world and as well, the women of every country that participated in the war, have acquired by that participation a new status. Many of the industrial difficulties of the present day are due to the resistance of working men and women everywhere, to being forced back to their former and inferior status. They are insisting that if they are good enough to place their lives at the disposal of the forces of civilization, then they are good enough to have at least some voice in determining the manner of life they shall lead in the civilization they have striven, they hope successfully, to preserve.
>
> In every country of the world the trend, for years, has been toward democracy; and absolutism, both in governments and in industries, is being generally perceived to be an anachronism in this age of enlightenment. . . . The tendency is to reëxamine our position with respect to our terrestrial environment and to ask why, with the productive powers of man multiplied by myriads of inventions, as they have been within the past century, anyone able and willing to work should, at any time, even temporarily, be without an adequate supply of all that is needed to maintain in good health not only himself, but all who are naturally dependent upon him; and to obtain in addition a fair share of the luxuries which modern civilization is supposed to afford for those who live in civilized countries. . . .
>
> Many of the most profound and disinterested students of this, our greatest problem, believe that the modern tendency of those who labor to plan for action in their common interest is, after all, the best protection society can have against worse things—evils such as have been alluded to above and which history plainly shows have led often to violence, but almost inevitably to degeneration and social decay.
>
> All who are sincerely trying to understand the present course of events will rejoice that, perhaps now more than ever before, men of large affairs, of proven capacity for leadership, heads of important industrial concerns, are giving evidence of their conviction that autocracy in industries is irreconcilable with democracy in governments. Realizing the very great difference between a body of employees all enthusiastically coöperating toward one object and, on the other hand, a body of employees rendering only such service as they think necessary to hold their jobs, and only so long as they wish to hold them, these men are giving this problem their best attention.

[1] 39th St. and Woodland Ave., Philadelphia, Pa.

Favors Printing Code of Ethics in Shape for Framing

The proposed Code of Ethics submitted by the Special Committee to the Spring Meeting at St. Louis (published in the September issue of MECHANICAL ENGINEERING) is worthy of careful consideration by each member of our Society.

The prospect of a definite, concise, straightforward code of ethics adopted by the A.S.M.E. to supersede the present rather cumbersome and lengthy code is gratifying. Any code of ethics that will stand the test is, or should be, merely restatements in detail of the operation of the Golden Rule, which has been the age-old measuring rod that has successfully withstood the assaults of the critic and the cynic and today will withstand the onrush of modern tendency to limit and equalize by restraint the service rendered for compensation or remuneration.

The Code, when adopted, might well be printed in such a shape that it can be framed, so that it may be in constant evidence. By displaying such a code in his office, the engineer subscribes to all of the statements contained therein. Such a use should go far toward inspiring confidence in the individual engineer and in the profession as a whole; for the Code, as proposed, is a statement of high altruistic purpose.—E. S. CARMAN.

Dr. Samuel Sheldon Dies

Dr. Samuel Sheldon, for the past thirty-one years professor of Physics and Electrical Engineering at the Polytechnic Institute of Brooklyn, died on September 4 at Middlebury, Vt. Dr. Sheldon was born in Middlebury on March 8, 1862. He was graduated from the Middlebury College in 1883 with the degree of A. B. In 1886 he received his A. M. degree. During the next two years he studied at Wurzburg, Germany, and received the degree of Doctor of Philosophy there in 1888. During part of this time he was associated with Kohlrausch, the distinguished physicist, in his celebrated determination of the ohm as the unit of electrical resistance. He was awarded the degree of Doctor of Science from the University of Pennsylvania in 1906, and from Middlebury College in 1911.

Dr. Sheldon was a fellow of the American Electro-Therapeutic Association, fellow and past-president of the American Institute of Electrical Engineers, member of the American Physical Society, member and past-president of the New York Electrical Society, member of the American Electrochemical Society, of the Society for the Promotion of Engineering Education, of the Brooklyn Institute of Arts and Sciences, and president of its department of electricity. He was also a member and past-president of the United Engineering Society and chairman of its Library Committee.

The Federated American Engineering Societies

First Meeting of Its Governing Body, American Engineering Council, to be Held in November, at Washington, D. C.—The Purposes and Activities of the New Organization—Two More Societies Become Charter Members

THE first meeting of the American Engineering Council, the governing body of The Federated American Engineering Societies, will be held on November 18 and 19, at the New Willard Hotel, Washington, D.C. This will be an event of the greatest importance to the engineering profession.

The first session will be devoted to the election of temporary officers and the appointment of temporary committees, and the second to an address by J. Parke Channing, chairman of Engineering Council. Mr. Channing's address will review the activities of Engineering Council and will outline particularly the work of its many committees. The second session will afford an opportunity for the discussion of the purposes of the Federation and its field of activities.

The sessions of the second day will be given over to the election of permanent officers and the reports of committees. Herbert C. Hoover, president of the American Institute of Mining and Metallurgical Engineers, will address the convention during this session.

A complete program of the meeting is presented below:

upon matters of common concern to the engineering and allied technical professions.

In the past Engineering Council has been fully alive to the need for concerted effort on the part of engineers in these directions and has accomplished notable results as already fully outlined in these columns. The following are some of the matters now pending before Engineering Council and with all of them the newly created American Engineering Council is destined to be greatly concerned.

- (*a*) Classification and compensation of engineers
- (*b*) Licensing of engineers
- (*c*) Water conservation
- (*d*) National Board for Jurisdictional Awards in the Building Industry
- (*e*) National Public Works Department
- (*f*) Assisting in the preparation of information for the Senate Committee on Reconstruction and Production
- (*g*) Public affairs
- (*h*) Military affairs

Program of First Meeting of American Engineering Council of The Federated American Engineering Societies

Washington, D. C., November 18-19, 1920: Headquarters, New Willard Hotel.

THURSDAY, NOVEMBER 18, 1920

MORNING SESSION

8:30 a.m. Registration

10:00 a.m. Opening Session of American Engineering Council

1 Call to Order
Richard L. Humphrey, Chairman of the Joint Conference Committee, Consulting Engineer, Philadelphia, Pa.

2 Election of Temporary Chairman

3 Election of Temporary Secretary

4 Appointment of Temporary Committees:
(*a*) Program
(*b*) Credentials
(*c*) Nominations
(*d*) Constitution and By-Laws
(*e*) Plan and Scope
(*f*) Budget
(*g*) Resolutions.

AFTERNOON SESSION

2:00 p.m. Address—ENGINEERING COUNCIL, by J. Parke Channing, Chairman.

2:30 p.m. Discussion of the field of activity for The Federated American Engineering Societies.

FRIDAY, NOVEMBER 19, 1920

MORNING SESSION

9:00 a.m. 1 Report of Committee on Nominations
2 Election of Permanent Officers
3 Report of Committee on Constitution and By-Laws
4 Formal Ratification of Constitution and By-Laws
5 Report of Committee on Plan and Scope

AFTERNOON SESSION

2:00 p.m. 1 Report of Committee on Budget
2 Report of Committee on Resolutions

EVENING SESSION

8:30 p.m. 1 Introductory remarks by the presiding officer, the Chairman of American Engineering Council
2 Address by Herbert C. Hoover, President American Institute of Mining and Metallurgical Engineers (Subject to be announced later)

9:30 p.m. Informal reception and smoker.

SATURDAY, NOVEMBER 20, 1920

9:00 a.m. Organization Meeting of Executive Board, American Engineering Council.

The Purposes and Activities of the Federation

Since the future activities of the newly organized Federation is bound to be the central topic under discussion at the forthcoming meeting of the American Engineering Council a statement of the work in prospect and a review of the accomplishment of the present Engineering Council is of timely interest.

The questions are frequently asked, "What will be the field of activity of The Federated American Engineering Societies?" and "What does the organization intend to do?" Briefly, it will so consolidate the engineers of the country that they will present a solid front and join in an united effort for the proper handling of governmental and legislative matters of an engineering character. It will use its power for the service of the community, state and nation in public affairs wherever engineering experience and technical knowledge are involved, and will consider and act

- (*i*) New York state government reorganization
- (*j*) International affiliation of engineers
- (*k*) Curricula of engineering schools
- (*l*) Patents
- (*m*) Payment for estimating
- (*n*) Booston-Washington super-power system
- (*o*) Russian-American engineering coöperation
- (*p*) Types of government contracts

In view of the good work which Engineering Council has accomplished and is now doing the questions arise:

If Engineering Council is a success, why should the proposed Federation supplant it?

If Engineering Council is a failure, why should the Federation be organized along lines so nearly parallel?

Chiefly, in answer to the first question, to establish an organiza-

tion which shall be representative of engineers everywhere so that all may have a voice and exert their influence in the great affairs of public concern with which a central body would be expected to deal. Engineering Council has six member-societies. At the Organizing Conference for the Federation 71 societies were represented with an aggregate membership of over 80 per cent of that represented by the 110 societies which were invited. As expressed in the bulletin of the Joint Conference Committee, which is now acting for the Federation, the organization of Engineering Council is "from the top downward," whereas the Federation, which came into being in response to a widespread movement throughout the country, has been organized from the "bottom upward" and rests upon a foundation so broad that every engineering society of acknowledged standing may become a supporting element.

The Constitution and By-Laws of the Federated American Engineering Societies for the first time provide a plan for bringing about solidarity in the engineering profession—a plan which assures success because it does not interfere with the existing engineering and allied technical societies.

The answer to the second question is that the Engineering Council has not been a failure, but on the other hand has done a magnificent work. The deficiencies of Engineering Council are not in the quality of the work which it has accomplished, but rather have been due to its organic limitations and to the fact that it is not sufficiently representative of the local, state and regional organizations and affiliations. The Organizing Conference in Washington laid the foundation for a more democratic organization in which the local, state, and regional engineering and allied technical organizations, and affiliations, will be represented, and will have a real voice in the management of its activities.

The Organizing Conference thus recognized the successes and limitations of Engineering Council and has evolved an organization in which all of these successes will be utilized and a broader opportunity afforded for more effective work on behalf of the engineering and allied technical professions.

Societies Rapidly Organizing for Federation Support

A. S. M. E. Appoints Its Delegates to American Engineering Council.

The Council of The American Society of Mechanical Engineers recently appointed its representatives on the American Engineering Council, the governing body of The Federated American Engineering Societies. The mechanical engineers will be represented by fourteen delegates who, under the By-Laws of the Federation, are appointed for a period of two years. A list of those named by the A.S.M.E. will be found on page 135 of Section Two.

American Institute of Electrical Engineers Becomes Charter Member.

The American Institute of Electrical Engineers is the second national engineering organization to join the Federation. This action by the Institute was taken at a meeting of the Board of Directors held in New York on August 12 when the following resolution were unanimously adopted:

Resolved, That the American Institute of Electrical Engineers accepts the invitation to it to become a Charter Member of The Federated American Engineering Societies, and pledges its hearty coöperation in the work thereof.

American Society of Civil Engineers to Vote on Joining Federation.

The American Society of Civil Engineers at a convention held in Portland, Oregon, during August voted to refer the question of joining the Federation to its corporate membership. The resolutions adopted provided:

"That the Board of Direction of the American Society of Civil Engineers be directed to submit at once the question of the American Society of Civil Engineers becoming a charter member of The Federated American Engineering Societies to referendum vote to the Corporate Membership of the American Society of Civil Engineers as recommended by the Joint Conference Committee, said ballot to be accompanied by a copy of the Constitution and By-Laws of said Federation, and

"That the Board of Direction of the American Society of Civil Engineers be further instructed in the event of a favorable vote on said referendum to proceed at once to take such steps as may be necessary for the American Society of Civil Engineers to become affiliated with said Federation."

Cleveland Engineering Society Is Fifth Member of the Federation.

The Cleveland Engineering Society at its meeting of August 10 voted to become a Charter Member of The Federated American Engineering Societies. The Cleveland society is the fifth organization to join the Federation, the first four in their order of affiliation being, respectively, The American Society of Mechanical Engineers, the Detroit Engineering Society, the Technical Club of Dallas, and the American Institute of Electrical Engineers.

THE CONSTRUCTION PERIOD

(*Continued from page 561.*)

land is $1,200,000 and the structural property $10,800,000. The purchase of land is started one year before construction and continues for three years, the construction period is also three years, the assessment is made in mid-year of each construction period. The assessor will find 70 per cent of the construction cost, the rate is 2 per cent. The amount put into property each year is as follows:

	Land	Structural Property	Total
First Year	$400,000	.....	$ 400,000
Second Year	400,000	3,600,000	4,000,000
Third Year	400,000	3,600,000	4,000,000
Fourth Year	.....	3,600,000	3,600,000
Total	$1,200,000	$10,800,000	$12,000,000

Solution:

Total cost end of first year	$ 400,000	
Cost at middle of first year	200,000	
Assessment @ 70%	140,000	
Taxes paid first year 2% of $140,000		$ 2,800
Total cost at end of second year	4,400,000	
Cost at middle of second year	2,400,000	
Assessment @ 70%	1,680,000	
Taxes paid second year 2% of $1,680,000		33,600
Total cost at end of third year	8,400,000	
Cost at middle of third year	6,400,000	
Assessment @ 70%	4,480,000	
Taxes paid third year 2% of $4,480,000		89,600
Total cost at end fourth year	12,000,000	
Cost at middle of fourth year	10,200,000	
Assessment @ 70%	7,140,000	
Taxes paid fourth year 2% of $7,140,000		142,800
Total taxes paid		$268,800

$$\frac{268,800}{12,000,000} = 2.24 \text{ per cent}$$

As in the cast of interest, before the final percentage to include for taxes during construction can be determined it will be necessary to know what method was used in finding the reproduction cost, if "piece-meal" the percentage will be one thing, if "wholesale" it will be another. The proper amount to include for taxes finally depends on first, the length of the construction period; second, what per cent of the construction cost will the assessor find; third, the tax rate.

Engineering Foundation Seeks Large Endowment

Research Organization Asks for $1,000,000 to Assure it of Adequate Funds for Present and Future Undertakings

THE Engineering Foundation, created in 1914 by the United Engineering Society, is now seeking to increase its endowment to at least a million dollars. The Foundation is based on gifts from Ambrose Swasey, of Cleveland, Ohio, Past-President Am.Soc.M.E., aggregating $300,000 and intended to be the nucleus for a much larger endowment fund. It was established "for the furtherance of research in science and engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind." Its income, however, is entirely inadequate to meet the ever increasing demands, and, in order that the researches now in progress may be continued and those contemplated be undertaken as may be required from time to time, an increase of endowment is thus being sought. The foundation desires gifts of $1000 or more, and it has announced that any person giving $250,000 will be honored as a Founder. Charles F. Rand, of 71 Broadway, New York, Past-President American Institute Mining and Metallurgical Engineers, is chairman of the Foundation. The offices of the Foundation are in the Engineering Societies Building, 29 West 39th Street, New York, Alfred D. Flinn, Secretary.

The endowment funds of the Foundation are owned by United Engineering Society, a New York corporation, for the four national societies. The income is administered by a board composed of thirteen representatives of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and three members at large. Because of the liberal form of its organization, the Foundation can support researches conducted either by individuals or by organizations; establish and operate research laboratories; aid in applying to engineering the results of the researches in the sciences, and in numerous ways aid in stimulating interest in research among engineers and the industries.

The results to be obtained through research cannot, however, be achieved in a short space of time, but, nevertheless, in its brief existence, Engineering Foundation has accomplished noteworthy results. Since 1916 it has maintained a liaison with scientists through the National Research Council, an organization called into being at the request of the President of the United States and which, because of its relation to the Federal Government, is therefore in a position to be intimately connected with the research problems both of the industries and governmental departments.

At present a most important research is being carried out, in which both the Foundation and the Division of Engineering of National Research Council are interested. It is concerned with the fatigue phenomena in metals. This highly important subject is being investigated at the Engineering Experiment Station of the University of Illinois and is being financed to the extent of $30,000 by the Foundation. Recently the General Electric Company requested that it be permitted to coöperate in the work in order that the program of tests might be extended. The September 1919 issue of MECHANICAL ENGINEERING contained a progress report of the committee appointed to carry on this research, and in it will be found a complete summary of the facts and theories relating to fatigue phenomena so far as at present known.

Another of the Foundation's researches is concerned with the wear of gears. This study begun in 1916 was interrupted by the war and was not resumed until the past summer. The work is being conducted at Leland Stanford Junior University.

In 1917 the Foundation joined with the New York Committee on Submarine Defense in a series of experiments on the concealment of ships by means of spray from special nozzles placed at suitable points on the vessel. This method of protecting ships was found, however, to be impractical.

One of the Foundation's most recent researches has resulted in an improved form of weir for gaging the flow of liquids in open channels. This research was conducted by Clemens Herschel, a noted hydraulic engineer, and a past-president of the American Society of Civil Engineers. The experimental work was conducted in collaboration with the Hydraulic Laboratory of the Massachusetts Institute of Technology and the results obtained were presented as the leading article in MECHANICAL ENGINEERING for February 1920.

Still another phase of research was undertaken in 1919, when the Foundation authorized Dr. E. E. Southard, the late Director of the Massachusetts State Psychiatric Institute, to undertake an investigation of the place in industry of the mentally deficient. The objects of Dr. Southard's research were to develop or discover methods for recognizing and suitably placing persons of slightly abnormal mental characteristics and for adapting psychopathic individuals to usefulness in industry, but his untimely death prevented the conclusion of his work. He had, however, completed three preliminary papers which appeared in the February, April, and June 1920 issues of *Industrial Management* (New York).

Research in mental hygiene of industry deals, however, with but one of the many groups of problems peculiar to industrial personnel relations. The Foundation has, therefore, coöperated with the National Research Council in planning a conference of leading industrial, labor and scientific bodies interested in this field to consider the possibility of comprehensive, unbiased study of the subject. Arrangements for the preliminary conference are well advanced and the meeting will be held this fall in Washington, D. C. Attention will be directed to the non-controversial elements of the subject, capable of scientific study.

In the latter part of 1918, Julius Alsberg, a consulting hydraulic engineer, suggested to the Foundation that there be established a station for the testing of large water wheels and other large hydraulic equipment. The Foundation immediately appointed a committee consisting of Silas H. Woodard, H. Hobart Porter, and Calvert Townley to investigate the matter. In May 1919, the committee reported that such a testing station was not feasible; that it was not necessary to establish a testing flume for small models, as existing flumes met all requirements; but that testing of water wheels now in place would be useful and practicable.

The Engineering Foundation has thus covered several diversified fields and has been limited as to the extent of its investigations solely because of its limited resources. Many important research projects which promised valuable results could not be undertaken because of lack of funds, and it is to provide for these that the Foundation is now engaged in increasing its endowment.

To those who desire more detailed information of its activities, the Foundation will be pleased to send a booklet descriptive of its organization and work.

Several calls for assistance have come to the Society from engineers in Austria, which indicate the desperate situation in which many are now placed in that country. The latest appeal comes from Innsbruck from the Technischer Verein Innsbruck, which says:

"To give you an instance of our precarious position, it would require, in consequence of the debasement of our money, the sevenfold amount of the entire funds of our society to procure a typewriter and a copying press, an amount which we would not be able to raise in addition to paying the current expenses of the society. We are in great need of these two machines in order to circulate items of a technical character among our members, and take the liberty of addressing ourselves to you and of soliciting your assistance in helping us to secure a second-hand typewriter and a copying press. Will you kindly send reply addressed to the Chairman of our Society, Mr. Julius Gruder, Engineer, Innsbruck, Postbox 79."

Government Activities in Engineering

Notes Contributed by The National Service Department of Engineering Council[1]

Organization and Status of Federal Power Commission

The Federal Power Commission which was created to administer the Water Power Act, passed and signed by the President in the closing days of the last Congress, has been organized along the following lines: engineering, accounting, statistical, regulatory, licensing, legal, and operation. It is apparent that the engineering division will be the most important because it will make general investigation of the electric power industry, power sites, costs, and development.

Unfortunately the actual work of the Commission has been somewhat hampered because the Comptroller of the Treasury has ruled that, under the terms of the act, there is no money available to pay the required personnel. This means that the personnel will have to be assigned to the Commission by the various Departments until such time as appropriations can be made to pay for the required assistance. Thus far Lt-Col. Kelley of the Engineers Corps has been assigned as engineer officer, and Major L. W. Call of the Judge Advocate General's office as chief counsel.

One of the chief duties of the new Commission has been to formulate regulations that would make the applications for water-power privileges valid. These regulations were drawn up by the Secretary and all interested Government Departments and outside organizations were invited to send their representatives to a Washington conference on August 12 for the purpose of discussion in making further recommendations. This meeting was followed by another conference the next day with representatives of interested financial institutions, so that their recommendations could also be considered before the application was put into final form.

Some regulations covering applications for permits and licenses under the Water Power Act were approved at the September 3d meeting of the Commission, and those covering construction, operation and maintenance of projects are now in process of preparation. It is contemplated that further hearings on these regulations will be held before they are finally adopted.

District offices of the Commission have been opened at St. Paul and St. Louis in the local offices of the Corps of Engineers, and in Denver and San Francisco in the legal offices of the Forest Service.

Effect of Navy Wage' Award on Salaries of Technical Men

On September 9 the Secretary of the Navy announced the new schedule of pay which had been made in accordance with the recommendations of the Navy Wage Adjustment Board. This is the first adjustment that has been made since the Macey Board Award in February, 1919.

In general, the various employees of the Navy receive increases of 5 per cent in pay except where the pay is more than eight dollars per day, so that the award does not include the engineers, architects, and draftsmen in the raise. In fact, they are adversely affected because the new schedule requires that all employees of the Department shall observe the standard working day of eight hours. This means that when the order becomes effective technical men will suffer a decrease of about 8 per cent in their present pay because of the loss of one-half day each week. This, combined with the fact that the working day is increased from seven to eight hours, makes an average approximate decrease of 20 per cent in compensation.

[1] Engineering Council is an organization of national technical societies created to consider matters of common concern to engineers as well as those of public welfare in which the profession is interested. The headquarters of Engineering Council are located in the Engineering Societies Building, 29 West 39th Street, New York City. The Council also maintains a Washington office with M. O. Leighton, chairman of the National Service Department, in charge. This office is in the McLachlen Building, 10th and G Streets, Washington, D. C. The officers of Engineering Council are: J. Parke Channing, *Chairman*; Alfred D. Flinn, *Secretary*.

National Committee for Governmental Economy

There are at least four important agencies carrying on a propaganda for some modification of the administrative branch of the Federal Government. These are, (1), the Budget Committee; (2), National Public Works Department Association; (3), National Education Association; (4), American Public Health Association.

Of these the National Budget Committee has taken the lead in the formation of a National Committee for Governmental Economy which is preparing a general plan for a reorganization of the administrative branch of the Government. This is for the purpose of coördinating the work of any departments which may be formed as a result of the proposed reorganization as, for instance, if a Department of Public Works is created, it is desired that this shall harmonize with other adjustments which must ultimately be made, and the same is true of the Department of Public Health or the Department of Education should they be formed.

The staff of the Committee comprises Stanley Howe, Director of Organization of the Budget Committee, who has the same duties with the new Committee; C. T. Chenery, Executive Secretary for the National Public Works Department Association, is Executive Secretary; and Harold N. Graves, Assistant Chief of the Bureau of Efficiency, is directing the reorganization study. The Committee has offices at 700 Tenth Street, N.W., Washington, D.C., and will issue progress reports from time to time.

Relative Importance of Mining and Agricultural Appropriations

Appropriations made by the last Congress show only one-thirteenth as much for the promotion of the interests of the mining industry as is shown for promotion of corresponding interests in the agricultural industry. The ratio of economic importance of these two industries is but one to four. Official reports for 1918 show that the total value of mineral products was roughly five and one-half billion dollars, while the value of agricultural products totalled approximately twenty-two and one-half billion dollars. Of course the agricultural industry is more diversified in all of its aspects, but those interested in the various phases of mining work contend that this does not make up for the great difference in ratio of expenditures.

It is now contended that the Bureau of Mines should assist the chemical industries in the same way that it extends its assistance to metal-mining and coal-mining industries, because of the fact that they are so closely allied to the Bureau's present work. It is hoped that the gathering of statistics and the study of problems pertinent to the chemical industries will be taken up by the Bureau of Mines during the next fiscal year.

Census of Central Electric Light and Power Stations

A partial report dealing with Central Electric Light and Power Stations for 1917 was issued by the Census Bureau on September 7. It is part of a more complete report which covers railways, telephones, telegraphs, and municipal electric fire alarm and police signaling systems, and which is the most complete and valuable census ever taken of American electrical industries.

The report which has just been issued covers the general development of Central Electric Light and Power Stations of both the steam and hydroelectric type. The general record of primary power equipment with special attention to generating equipment, line equipment and substation equipment is also presented, and the output and disposal of current is classified. Very comprehensive financial statistics are also given with special comparative financial and operating summaries of selected groups of electric stations. The report likewise contains some interesting data on employees, salaries, and wages.

Mining Engineers Visit Lake Superior Copper and Iron Country

The 122d Meeting of the Institute of Mining and Metallurgical Engineers Held at Points in Michigan and Minnesota, with Inspection Trips to the Great Mining Properties of Lake Superior District

A GENERAL trip of study and inspection of the Lake Superior iron and copper country was a feature of the 122d meeting of the American Institute of Mining and Metallurgical Engineers. Members left Buffalo on August 20, visited the copper mines in and about Houghton, the iron mines of the Marquette and Iron Ranges of Michigan and those of the Mesabi Range in Minnesota, and returned to Buffalo on September 3. Technical sessions were held at Houghton, Minneapolis and Duluth. A banquet was also held at Minneapolis, Herbert Hoover, President of the Institute, delivering the principal address.

Address by Herbert Hoover

Mr. Hoover spoke in advocacy of a definite national program in the development of our great engineering problems and emphasized the need for a National Department of Public Works. He said in part:

Our rail and water transport, our water supplies for irrigation, our reclamation, the provision of future fuel resources, the development and distribution of electrical power, all cry out for some broad-visioned national guidance. We must create a national engineering sense of provision for the nation as a whole. If we are to develop this national sense of engineering and its relations to our great human problems it must receive the advocacy of such institutions as this.

We, together with our sister engineering societies, represent the engineers of the United States. It is our duty as citizens to give voice to those critical matters of national policy which our daily contact with this, the fundamentally constructive profession, illuminates to us. Just as our medical associations voice the necessity of safeguards to national health; as the bar associations safeguard our judiciary, so the engineers should exert themselves in our national engineering policies. We have none, but we need some, or the next generation will face a lower instead of a higher standard of living than ours.

Continuing, Mr. Hoover discussed the great national engineering problems of coal and petroleum supply, rail and water transportation, mountain water storage, irrigation, lumber supply, etc., and said:

All these problems are much akin, and the time has come when they need some illumination, guidance, and coöperation in their solution from the Federal Government. Nor do I mean a vast extension of Federal bureaucracy in Federal ownership. If, in the first instance, through an agency of the central government, we could have an adequate study and preparation of plan and method made of these problems of engineering development over the next fifty years, viewed solely in their national aspects, we would have taken the first step toward the adequate provision of an increasing standard of living and a lower cost of living for our descendants.

The second step is to determine that our government will be a government of coöperation, limiting profits surely, but holding to individual initiative as the single hope of human development. In order that we shall have some central point in the Federal government where these problems may be adequately considered, from which they can be ventilated for the verdict of public opinion, where the business brains of the country can be called into conference and coöperation with the government, and therefore with the people, the engineers of the United States have proposed time and again that a Cabinet department should be established in Washington, either new or to replace the Interior Department, to which should be assigned the whole question of public works. . . .

Such a department has become an essential from the point of view of proper consideration and presentation to the American people of these broader national engineering problems, upon which the next generation must depend if our country is to march forward.

Technical Papers

A paper on the Handling and Treatment of Rock-Drill Steel at Copper Range Mines was presented by H. T. Mercer and A. C. Paulson. The shank is formed in a bulldozing machine, a pin 5 in. long being first inserted in the hole to maintain it. After being formed the pin is removed and the shank reheated and quenched in oil. A 1/64-in. clearance is allowed between the shank and drill chuck. All shanks are made without lugs, except in a few cases where the drills are to be used in loose ground. Collars are formed on the Jackhammer steel only. Results obtained in heat-treating experiments were also mentioned. Drills were suspended in a chloride bath and the heat regulated by a pyrometer. They were then quenched in tempering oil, a 10 per cent solution of brine, or water, and tests run on each in the mine under uniform conditions. Other tests were made with a further treatment by tempering or drawing. It was concluded that the additional treatment after hardening was altogether unnecessary. No practical difference was found between heating in a chloride bath or in a coke furnace, provided temperature regulation was maintained equally as well in both cases. Water at a temperature of 80 to 100 deg. fahr. was determined to be the best quenching medium for the conditions existing in the mines.

How steam regenerators reduce coal consumption at the mines of the Copper Range Company was told by W. H. Schacht. The hoists furnish the only available supply of exhaust steam. The method of treating a flux of intermittent exhaust steam by the use of steam regenerators consists in passing the steam through a closed vessel, or regenerator, in which it is condensed and re-evaporated. Condensation takes place when the steam is in excess of the quantity required to maintain a constant flow of outgoing steam, and reëvaporation takes place when the steam discharged into the regenerator is not sufficient to maintain this constant flow. The steam from the regenerator is delivered to the buildings to be heated with a drop in pressure not exceeding 2 lb. at times of greatest demand and about 1 lb. during average winter conditions. A two-pipe system is used. In the buildings the drainage of mains and return lines is in the direction of the flow, thus eliminating all water hammer. Syphon traps are used on all radiators, direct and indirect, and on all headers and drips. The air and condensation are collected into and returned by a 3-in. line, the end of which is submerged, forming a water seal that is located in the boiler house. At a point about 20 ft. above the overflow of this water seal is located an air separating tank, from which the air and non-condensable vapors are drawn from the system by a Nash No. 0 vacuum pump, requiring for its operation about 1½ hp. This pump is operated by an electric motor. The pressure carried on the regenerator, being also the back pressure on the hoist, varies from 8 to 10 in. vacuum to ½ lb. above the atmosphere; the colder the weather, the lower is the average of the range maintained. The return-line pressure is usually constant at about 18 in., making a working pressure available, therefore, of about 8 lb., which is more than sufficient in almost any emergency. There was a slight reduction in the tons hoisted in most plants during the year following the regenerator installations, but this did not affect the coal consumption materially, for some live steam was usually required for heating.

Surface Changes of Carbon Steels Heated in Vacuo, by E. Heaton Hemingway and George R. Ensminger, contained an account of experiments conducted at the Watertown Arsenal. Samples of steel were held at 1000 deg. cent. in vacuo for 10 hours. Three types of markings were discerned: (1) A deeply marked polyhedral structure, which represented the final gamma boundaries; (2) a fine clean-cut structure, which was brought out more clearly by etching, that represented the alpha boundaries; and (3) an indefinite and often partly obliterated structure that represented the boundaries of former gamma crystals that had been absorbed by crystalline growth. The outside layer consisted of ferrite as result of the iron having been volatilized and redeposited below the temperature at which solid solution exists. Iron oxide reacted with the carbides in steel at temperatures below 1000 deg. cent. to form carbon monoxide and pure iron.

Other papers were presented, among which were the following: Efficiency in the Use of Oil as Fuel, by W. N. Best; Industrial Representation in the Standard Oil Co. (N. J.), by C. J. Hicks; A New Process for Making Fifteen Per Cent Phosphor Copper, by P. E. Demmler; and The Charpy Impact as Applied to Aluminum Alloys, by E. H. Dix, Jr.

LIBRARY NOTES AND BOOK REVIEWS

A Course in Electrical Engineering. Vol. I. Direct Currents. By Chester L. Dawes. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6 x 8 in., 426 pp., illus., $4.

The present book is the first of two volumes which are intended to serve as a comprehensive text covering the general field of electrical engineering in a simple manner. It will be useful, the author believes, to students of electrical engineering as an introduction to more advanced texts and also to students who are studying the subject for general training, without the intention of becoming specialists. The treatment is detailed, straightforward and systematic, but avoids much mathematical analysis.

The Design of Highway Bridges of Steel, Timber and Concrete. By Milo S. Ketchum. Second edition, rewritten. McGraw-Hill Book Co., Inc., New York, 1920. Flexible cloth, 6 x 9 in., 548 pp., illus., diagrams, charts, tables, $6.

This new edition has been made necessary by the increase in live loads due to the extensive use of heavy motor trucks and tractors, and the increased use of reinforced concrete in highway bridge construction. The scope of the book has been extended to include the design of concrete and timber bridges as well as steel bridges. The discussion covers all the details of constructing highway bridges. This edition is uniform with the author's Structural Engineers' Handbook.

Dredging Engineering. By F. Lester Simon. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6 x 9 in., 182 pp., illus., plate, tables, $2.50.

The author of this volume has attempted to supply a work which will describe the principal types of dredges in such a manner as to impart a fundamental working knowledge of their construction and operation. He also takes up concisely the problems that confront the engineer in the conception and accomplishment of dredging projects.

Earthwork and Its Cost. A Handbook of Earth Excavation. By Halbert Powers Gillette. Third edition. McGraw-Hill Book Co., Inc., New York, 1920. Flexible cloth, 5 x 7 in., 1346 pp., illus., tables, $6.

This treatise covers systematically and comprehensively the methods of excavating for engineering work of all kinds. In addition to the results of his own experience, the author has included a summary of the material in American technical literature. Particular attention is given to cost data. The present edition has been revised.

Flugtechnik: Grundlagen Des Kunstfluges. By Arthur Pröll. R. Oldenbourg, München and Berlin, 1919. Paper, 9 x 12 in., 332 pp., illus. 30.25 marks (33 marks, pound).

This treatise is founded on a manual of the scientific foundations of the subject, prepared for practical self-instruction while the author was director of the aeronautical experiment station of the Austrian war ministry. The notes prepared for this purpose were used later in connection with his lectures on technical aerodynamics in the Hannover High School, from which the present work has been prepared. The book, therefore, presents the subject from the viewpoint of immediate practical usefulness and also emphasizes the connection of aeronautical calculations with the teachings of mechanics. It will serve, the author believes, not only as a text for students, but will also enable the experienced engineer to carry out designs and construction in all details, when combined with practical numerical data. The discussion is confined to monoplanes and biplanes of the usual type.

How to Manage Men. The Principles of Employing Labor. By E. H. Fish. The Engineering Magazine Co., New York, 1920. Cloth, 6 x 9 in., 337 pp., $5.

This volume is a discussion of the relations between workers and their employers, in which an attempt is made to evaluate the things that go to make a satisfactory working organization. The author discusses the establishment of an employment department, the problems of the employment manager, the promotion of industrial relations, and industrial education.

The Iron and Steel Industry of the United Kingdom Under War Conditions. A Record of the Work of the Iron and Steel Production Department of the Ministry of Munitions. By F. H. Hatch. Privately printed for Sir John Hunter by Harrison and Sons, London, 1919. Cloth, 6 x 10 in., 167 pp., illus., plates, portraits, charts, tables.

This volume is an interesting account of the methods used by the British Government to obtain the necessary increase in the steel production of Great Britain during the war. The vastness of the field covered, the variety and complexity of the technical problems involved and the far-reaching industrial questions raised, make the subject one of great interest and importance.

MacRae's Blue Book. MacRae's Blue Book Co., Chicago and New York, 1920. Cloth, 9 x 11 in., 1853 pp., $10.

An alphabetically arranged directory of American manufacturers, which is especially full with respect to iron and steel products, and the materials used by railways and in building. In addition to the directory of materials it contains a list of addresses, and also of trade names, a standard list of prices and a collection of data used by buyers. Thirty thousand firms are included.

Marine Engineers' Handbook. Prepared by a staff of specialists, Frank Ward Sterling, Editor-in-Chief. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Flexible cloth, 5 x 7 in., 1486 pp., illus., tables, $7.

This handbook is compiled for the use of operating and designing engineers, and students. To cover the main subjects and the many ramifications of marine engineering, it has been necessary to enlist the services of thirty specialists, each of whom has received the hearty coöperation of others in the same field. The best endeavor has been made to coördinate different practices in order that all data may be reliable and unbiassed. The handbook is a pioneer in its field.

Mathematics for Engineers. Part II. By W. N. Rose. E. P. Dutton and Co., New York, 1920. Cloth, 6 x 9 in., 419 pp., illus., tables, $7.

The work of which this is the second volume is intended to occupy a position midway between those written for college students, which are usually academic in character, and those practical books which omit any discussion of the scientific basis underlying them. It is intended to contain all the mathematical work needed by engineers in their practice and by students of all branches of engineering. This volume treats of the differential and integral calculus, spherical trigonometry and mathematical probability.

Personnel Administration. Its Principles and Practice. By Ordway Tead and Henry C. Metcalf. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6 x 9 in., 538 pp., $5.

The purpose of this book is to set forth the principles and the best prevailing practice in the field of the administration of human relations in industry. It is addressed to employers, personnel executives, employment managers and students of personnel administration, but will have value, the authors hope, also for all who are interested in advancing right human relations in industry and in securing a productivity that is due to willing human coöperation, interest and creative power. The field covered includes those efforts usually included in personnel management, employment, health, and safety, training, personnel relations, service features and joint relations. The book also seeks to show the relation of the personnel problems of each corporation to those of its industry as a whole, by considering the activities of employers' associations and organizations of workers.

Railroad Curves and Earthwork. By C. Frank Allen. Sixth edition, revised. N. Y. and London. McGraw-Hill Book Co., Inc., New York, 1920. Flexible cloth, 4 x 7 in., 289 pp., diagrams, charts, tables, $4.

This book has been prepared for the use of the students in the author's classes at the Massachusetts Institute of Technology, but it will also, he believes, be useful to engineers who have to deal

with earthwork computation or curves. The new edition is marked by an extension of the treatment of circular arcs; by new methods for the computation of earthwork, additional data on haul, and by general revision.

THE RUDDER MARINE DIRECTORY. A Trade List of Shipbuilding and Marine Industries. Rudder Publishing Co., New York, 1920. Cloth, 6 x 9 in., 438 pp., $5.

The title of this directory is sufficient indication of its contents, and suggests its possible usefulness to those interested in ship construction and operation. The present edition is considerably larger than the first, which appeared in 1919. The lists are conveniently classified and arranged to facilitate their use.

DIE SCHALTUNGSGRUNDLAGEN DER FERNSPRECHANLAGEN MIT WAEHLERBETRIEB. By Fritz Lubberger. R. Oldenbourg, München & Berlin, 1920. Boards, 9 x 13 in., 168 pp., plates, 28 marks.

This book is intended to give engineers acquainted with manually-operated telephone exchanges an introduction to automatic systems, which are frequently so confusing to the beginner. The author has made an extended examination of the systems of wiring used or proposed for this purpose and has selected the essentials of proper procedure from them. Beginning with an easily understood automatic circuit, the book then proceeds to describe generally the principles of the various parts of the circuit, and follows this with explanations of the various systems that have been devised for the practical solution of the problems involved. The book includes bibliographical references, a list of German patents and many plates illustrating the arrangements described.

STORAGE BATTERIES. A Practical Presentation of the Principles of Action, Construction, and Maintenance of Lead and Non-lead Batteries and their Principal Commercial Applications. By Morton Arendt. American Technical Society, Chicago, 1920. Flexible cloth, 6 x 7 in., 136 pp., illus., plate, tables.

Important changes have taken place with the last ten years in the construction of the storage battery, and the principles of the design and manufacture of this "savings bank" of the electrical industry have been studied with the view of making it even more efficient. The importance of proper charging methods, testing, locating and remedying troubles are treated in detail in this volume, which also covers the methods of use by the large generating stations, in the telephone and telegraph industries and in electric vehicles. The work is adapted for home study by beginners as well as for experts.

STRUCTURAL STEELWORK. Relating Principally to the Construction of Steel-framed Buildings. By Ernest G. Beck. Longmans, Green and Co., New York, 1920. Cloth, 6 x 9 in., 462 pp., illus., tables, $7.50.

This book presents information likely to be of use in the design and construction of ordinary steel-framed structures. The principal endeavor has been to be broadly suggestive, rather than particular or exhaustive, to propose commonsense lines of argument based upon straightforward consideration of the facts, instead of attempting to generalize or formulate specific relations from details which cannot be more than typical. The work follows British practice, and is based upon a series of articles contributed to the *Mechanical World*.

TEXTBOOK OF AERO ENGINES. By E. H. Sherbondy and G. Douglas Wardrop. Frederick A. Stokes Co., New York, (Copyright 1920). Cloth, 9x12 in., 363 pp., illus., diagrams, plates, $10.

The present work is a review of the theory and practice of the design of engines for aerial navigation. The first part treats of theory and includes the theory of the cycle, the work available, the effect of altitude, pressure, etc., on the power, and the theory and design of compressors. The second part describes the current types of American, British, French, German and Italian engines. An appendix gives tables of use to designers. The book is fully illustrated with drawings and photographs.

TECHNICAL GAS AND FUEL ANALYSIS. By Alfred H. White. Second edition, revised and enlarged. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6x8 in., 319 pp., illus., tables, $3.

The first edition of this work, which appeared in 1913, was intended to present the conclusions of the various committees of technical societies which had reported on the testing of fuels and their utilization. Since 1913 our knowledge of gas and fuel analysis has been distinctly increased. Standard methods for sampling and analyzing coal and coke and for examining liquid fuels have been adopted by several societies. Methods for gas analysis have been critically studied and new methods developed. These advances have been carefully reviewed for this edition, which is about 20 per cent larger than the former one.

UTILISATION DES VAPEURS D'ECHAPPEMENT DANS LES HOUILLERES en Vue de la Production d'Energie Electrique. By Adrien Barjou, preface by Maurice Soubrier. Gauthier-Villars et Cie., Paris, 1920. Paper, 6x10 in., 90 pp., illus.

The author of this work discusses the utilization of exhaust steam in low-pressure turbines for the production of electricity or compressed air. The particular case studied is that of coal mines which have outgrown their power plants and are faced with the necessity of extending them. The economic and technical results obtained with low-pressure turbines are set forth in this book.

WIRING FOR LIGHT AND POWER. A detailed and fully illustrated commentary on the National Electrical Code. By Terrell Croft. Second edition. McGraw-Hill Book Co., Inc., New York, 1920. Flexible cloth, 5x8 in., 465 pp., illus., tables, $3.

The purpose of this book is to supply explanations, elaborations and illustrations for those sections of the National Electrical Code to which most frequent reference is necessary. For this purpose the most important Code regulations are given verbatim, and their application in practical electrical construction is explained by supplementary text and drawings. This edition has been fully revised to correspond with the 1918 edition of the Code.

THE EFFECT OF DEPTH OF COPPER PLATING ON CARBURIZATION

(*Continued from page 566.*)

An ocular micrometer was used to measure the depth of case. The depth t of the plating was calculated from the formula t (inches) $= C/145.845A$, in which C = weight of copper deposited, grams; 145.845 = weight of 1 cu. in. of copper, grams (assuming specific gravity = 8.9); and A = area of surface of deposit, sq. in.

Data from tests of sets B, D and E are given in Table 1. From these it may be seen that the carbon had just started to leak through the copper plating and in all specimens, including those of sets A and C, there was no case below the copper that would ever be noticed in practical work. The amount of copper which analysis does not show and which is due to solution in the iron or any other cause at all is certainly low; and allowing 10 per cent for this would give a safe margin. It is believed that for a 10 to 12 hour heat not over 0.0002 in. need ever be used. In event such an amount of copper is used the only care that should be taken is to have plenty of the carburizing agent present so that it will not be exhausted and the copper oxidized by reaction in which $2CO_2+Cu$ becomes $CuO+2CO$.

In examining the specimens under the microscope the corners of the pieces were given considerable attention. At this point the carbon could enter the steel back of the copper. In some 60 per cent of all specimens, however, such was not the case, and it seemed that the copper exerted some influence to keep carbon from the steel even though it was not directly in contact with it.

The photomicrographs taken—Figs. 1 to 6—show the typical appearance of specimens examined. With the exception of the original, these pictures were taken of piece No. 30; they show very clearly that no carbon penetrated the copper, and that at the same time a good cementation was effected on the back.

These experiments would tend to show that in copper plating with a current of as low density as the one employed:

1 There is no need of using as deep a plating as is now common practice;

2 The depth of copper plating required for ordinary work is not over 0.0002 in., or with a 100 per cent safety factor, 0.0004 in., and very often a lesser thickness would be sufficient.